SCIENCE ABSTRACTS.

Section A.—PHYSICS.

SEPTEMBER 1921.

GENERAL PHYSICS.

1507. *Constant-Current Type of Hot-Wire Anemometer.* **J. S. G. Thomas.** (Phil. Mag. 41. pp. 716–732, May, 1921.)—*Apparatus.*—A form of hot-wire anemometer is described in which the heating current is maintained constant, and the cooling effect experienced by the exposed wire due to a small impressed velocity of the gas stream, compensated by alteration of the inclination of the wire from its initial horizontal position. The limits of application of such a device are shown by a series of calibration curves, in which the necessary alteration is plotted against the value of the impressed velocity, for values of the heating current ranging from 0·9 to 1·5 amps. The results are employed to deduce the value of the effective free convection current corresponding to any given inclination of the wire when heated by the respective electric currents. The alteration in the effective velocity of the free convection current accompanying alteration in the inclination of the wire is utilised to determine the inferior limit of the value of the impressed velocity of the stream for which the effect of the free convection current may be safely neglected. Empirical linear formulæ are obtained relating such limiting velocities to the temperature of the wire. The effect of the free convection current upon the form of the calibration curves is illustrated by reference to the forms of the curves obtained employing two values of the heating current for both the horizontal and vertical dispositions of the wire, and for various inclinations of the wire employing a constant heating current.

AUTHOR.

1508. *Molecular Elastic Forces and the Resultant Vibrations.* **M. Cantone.** (Accad. Lincei, Atti, 29. ii., pp. 249–257, Oct., 1920.)—A discussion from the point of view of discrete molecules. Broadly, the results are similar to those of the classical treatment in isotropic media; but aeolotropic media present specialities.

A. D.

1509. *Impact on Elastic Plates.* **K. S. Rao.** (Indian Assoc. for Cultivation of Sci., Proc. 6. Parts 3 and 4. pp. 165–173, 1921.)—The assumptions forming the basis of Raman's extension of the theory of Hertz have been tested experimentally, and it is shown how the residual discrepancies between observation and the results of Raman's theory in the case of thin plates may be explained. Except for thin plates the duration of impact is found to be substantially the same as that given by Hertz's theory of impact on an infinite mass of solid with a plane face. But when the thickness of the plate is diminished to nearly the critical value (at which the whole of the energy of the impinging body is transformed into energy of wave motion), experiments show an appreciable increase in the duration of contact. With suitable modifications, the theory seems to be capable of application to the problem of the analysis of the vibrations of plates or bells excited by impact. [See Abs. 1361 (1920).] E. H. B.

1510. *Quantum Theory and Homogeneous Vibrations.* **A. Schuster.** (Nature, 107. p. 233, April 21, 1921.)—The author observes that in the quantum theory, as usually presented, a finite energy is associated with a vibration which is called " homogeneous." But hitherto a homogeneous vibration has been understood as one unlimited in time, as a homogeneous wave is unlimited in space. A disturbance having velocities porportional to $\cos nt$ is homogeneous only if it applies to the values of t, however great, positive and negative. The radiation of a quantum, if expressed by a circular function, being necessarily limited in time, homogeneity is impossible. If the velocity of an oscillator be expressed by $e^{-kt \cos nt}$, the exponential function admits quanta because it allows a finite value to be assigned to the energy. When analysed practically by the spectroscope, or theoretically by Fourier's theorem, all frequencies are represented, though when k is small nearly the entire energy is concentrated in a narrow region closely adjoining that of the maximum intensity which occurs at frequency $(n^2 - k^2)^{1/2}$. The radiation associated with a quantum is, therefore, not homogeneous, though its effective energy is confined to a narrow region of frequencies. If an expression be required to denote the nearly homogeneous radiation of a quantum, it might well be termed a " quantum radiation." G. W. DE T.

1511. *Motion of a Simple Pendulum after the String has become Slack.* **A. T. Jones.** (Phil. Mag. 41. pp. 809–813, May, 1921.)—Morton has previously discussed the case where the jerk, occurring at the point where the pendulum bob's parabolic path intersects the circle, is treated as perfectly inelastic [Abs. 515 (1919)]. In the present note it is treated as perfectly elastic. L. H. W.

1512. *Transverse Vibrations of Prismatic Bars.* **S. P. Timoshenko.** (Phil. Mag. 41. pp. 744–746, May, 1921. From the Russian.)—Mathematical.

1513. *Colours and Brownian Movements of Ultramicroscopic Metallic Particles.* **R. Fürth.** (Phys. Zeits. 22. pp. 80–87, Feb. 1, 1921.)—Investigation as to the manner in which these depend on the radii, in theory and experimentally. A. D.

1514. *Surface Tension of Mercury in Various Gases.* **J. Popesco.** (Comptes Rendus, 172. pp. 1474–1476, June 13, 1921.)—The apparatus employed in the experimental determinations (" large drop " method) is described, and a table of results given for NH_3 and SO_2 for periods up to 24 hours. The surface tension is shown to decrease rapidly in the first ten minutes. The results with air are also given. It is suggested that the phenomena are not due to chemical action but to adsorption.

A. B. C. L.

1515. *Motion Determinations of an Isolated Solid.* **G. Lippmann.** (Comptes Rendus, 172. pp. 557–561, March 7, 1921.)—Assuming the body to be a homogeneous rigid sphere of known radius and known constant density, pendulum observations, timed by a chronograph, at three points on the surface, chosen at random, of the acceleration at each point, give three equations between the three accelerations and the angular velocity as of the form $g_i^2 = g^2 + (a^2\omega^4 - 2ga\omega^2)\sin^2\lambda_i$, where g has the value $4\pi a\rho G/3$, ρ being the density and G the gravitation constant, and λ_i being the latitude of the point at which the acceleration is g_i. These, together with the known relation between the squares of $\sin\lambda_i$, determine ω and the polar axis. If the three stations be taken at distances of 90° apart, the addition of the three equations gives $a\omega^2 = g - \left\{(g_1^2 + g_2^2 + g_3^2 - g^2)/2\right\}^{1/2}$. The direction of rotation may be found from such phenomena as the deflection of falling bodies.

E. Picard (*ibid.*, pp. 629–630, March 14, 1921).—The problem may also be solved by first determining the direction of the axis by means of a gyroscope. A gyroscopic compass will give the meridian plane, determining the latitude. A Foucault pendulum will determine ω, since the plane of oscillation turns with the angular velocity $\omega\sin\lambda$. Or ω might be found by following the rotary movement of the gyroscopic axis about the parallel to the axis of the planet.

L. Le Cornu (*ibid.*, p. 731, March 21, 1921).—Whatever the form and constitution of the planet, a Foucault gyroscope would determine a set of fixed directions, *e.g.*, a trihedral trirectangle. The apparent rotation of the trihedron relatively to axes fixed in the planet can then be found, giving the direction of the instantaneous axis of rotation at any time. The latter would apparently describe a second-order cone having axes parallel to the principal axes of inertia through the centre of gravity of the planet, thus determining the direction of the latter. Hence the ratios of the components p, q, r, at any instant, of the variable rotation ω about the principal axes could be determined. With the aid of a chronograph, p, q, r, and w could then be found. Theoretically, we may proceed further. Being given p, q, r as functions of the time, the known equations of motion of a free solid about its centre of gravity will, in the absence of external forces, give the ratios of the central moments of inertia, A, B, C. Then calculating the ratios of Ap, Bq, Cr, we obtain the parameters determining the direction of the moment of momentum, and therefore also of the plane of maximum areas perpendicular thereto. An experimental verification might be obtained by showing by aid of a gyroscope that the absolute orientation of this plane actually remained invariable.

G. W. DE T.

1516. *Mechanical Equilibrium of a Fluid Gravitating Sphere.* **C. H. Lees.** (Phys. Soc., Proc. 32. pp. 265–270, Aug. 15, 1920, and 33. pp. 116–123, Feb., 1921.)—Kelvin has shown [Manchester Lit. and Phil. Soc., Proc. [Ser. 3.] 2. p. 125, 1862] that convection currents in the earth's atmosphere, if dry, would cause the average temperature θ of horizontal layers to decrease with height h in accordance with a law of "convective equilibrium," $-d\theta/dh = (\gamma - 1)g/\gamma R$, where γ is the ratio of the specific heats of air at constant p and v, g is the gravitational acceleration, R the gas constant, and v is the volume of 1 gm. of air at the point considered, the equilibrium then being neutral. If $-d\theta/dh$ be greater or less the equilibrium will be unstable or stable respectively. Observation gave the theoretical result when the allowance was made for the heat developed by condensation of the moisture present. Laue [Am. J. Sci. 53. p. 57 (1870)], Kelvin [Phil. Mag. 22. p. 287 (1887), Abs. 1043 (1908)], and Jeans [Cosmogony and Stellar Dynamics, p. 191 (1919)] have extended this to spherical gaseous masses under their own gravitations, assuming the perfect gas equation satisfied. If for this gas when adiabatically expanded $p = A\rho^{\gamma}$, where ρ is the density, Kelvin called A the "adiabatic constant," for neutral or convective equilibrium. A is constant throughout the gas at any instant, but decreases with lapse of time; and for stable equilibrium must increase from the centre to the circumference, as was implied in the reasoning of Laue and Kelvin, but was first stated explicitly by Jeans [*loc. cit.*].

The object of the present paper is to show that a criterion of any gravitating fluid or mixture of fluids may be established, where by fluid is understood a medium in which the pressure is of the hydrostatic type—has the same value in all directions about an internal point. Solids under great pressure probably come within this category along with liquids and gases. From Clairant's theorem—that if in a fluid we draw a surface everywhere perpendicular to the direction of the gravitational force at points within it, that surface is a surface both of equal pressure and of equal density, whether the medium be homogeneous or not—it follows that if the gravitational force has the same value at all points of such a surface, the surface must be spherical, and the surfaces of equal gravitational force, equal pressure and equal density are all concentric spheres. It is then easily shown thermodynamically that $dv/dr > g\beta_{\phi}$, where β_{ϕ} is the adiabatic compressibility at the point, is the condition for stable equilibrium; the two must be equal for neutral and the latter exceed the former for unstable equilibrium. And this holds for a fluid mixture of any composition whose specific volume and adiabatic compressibility are known or calculable. And the latter is always calculable from the observed isothermal compressibility β_{θ}. For a perfect gas $\beta_{\phi} = 1/\gamma p$; while for liquids $\beta_{\phi} = \beta_{\theta}$ to a degree of approximation sufficient for many purposes. If the entropy ϕ of 1 gm. of the fluid is expressible in terms of its v and p, which will be the case if the fluid be homogeneous, it is shown that the condition for stable equilibrium is $d\phi/dr > 0$. If the state of a homogeneous medium is defined in terms of p and θ, the condition for stable equilibrium may be expressed in the form $-d\theta/dr < g\theta(\partial v/\partial\theta)_p/c_p v$, where c_p is the specific heat at constant pressure. If the fluid be not homogeneous throughout, but consists of a number of homogeneous media which do not dissolve each other, the various media will for stable equilibrium be arranged in concentric spherical shells, subject to these three equivalent conditions being satisfied in each homogeneous shell, while at each separating sphere v must not decrease as r increases. Hence the second statement takes the form: For stable equilibrium $d\phi/dr$ at any point must exceed the rate of increase of ϕ due to change of composition of the fluid at that point. Since ice is in equilibrium on the surface of water, the entropy per gm. of the upper material need not always exceed that of the lower. As the conditions of thermal equilibrium at a surface separating two fluids are that the heat fluxes and temperatures on the two sides shall be equal, it may be convenient to write the condition for stable mechanical equilibrium of each fluid in the form $-kd\theta/dr < kg\theta(\partial v/\partial\theta)_p c_p v$, where k is the rate of transmission of heat per sq. cm. per sec. for unit slope of temperature. It may occasionally happen that the equilibrium first becomes stable in each of two contiguous fluids at the same instant, in which case there will in general be an abrupt change in dv/dr across the interface. The probability of convective and thermal equilibrium occurring together in contiguous layers is small, but it is shown that they may subsequently be in stable mechanical and thermal equilibrium with each other. Convection currents in the sphere while in the unstable state will, in general, ensure the complete mixture of two miscible fluids, but the equilibrium may become stable before mixture is complete. Suppose, then, the fluid to be a mixture in varying proportions of a number of fluids which mutually dissolve each other. Stable equilibrium will then be possible only if v is uniform throughout each thin concentric shell and increases from shell to shell outwards; the diffusion is then superposed on the phenomena under consideration and the condition for stable equilibrium is still $dv/dr > g\beta_\phi$, but the other two forms hitherto equivalent to it are shown to require slight modification. These two afford connecting links between the problem of mechanical stability and the equally important one of thermal stability. G. W. de T.

1517. *Determination of the Coefficient of Normal Viscosity of Metals.* **K. Honda** and **S. Konno.** (Phil. Mag. 42. pp. 115–123, July, 1921.)—After a mathematical discussion of the coefficients of normal and tangential viscosity in solid substances, an apparatus is described for determining these coefficients by observing the period and logarithmic decrement of a weight swinging at the end of a band of the metal under investigation. By means of this apparatus, the coefficients of normal viscosity for Ag, Al, Cu, Zn, Mg, Ni, a rolled 60/40 brass, and five carbon steels were determined, in most cases both as rolled and after annealing. In addition, experiments were made with copper bands of various dimensions to test the results obtained mathematically on the effect of dimension. It is found that, except in the case of zinc, the coefficient of normal viscosity of the metals investigated is between 1 and 10×10^8 c.g.s. units, that of rolled zinc being $27{\cdot}4 \times 10^8$ units. Generally speaking, annealing causes a diminution of the coefficient, but copper is an exception to this rule. The coefficient of normal viscosity is of the same order as the coefficient of tangential viscosity, and in the case of steel the viscosity increases with the carbon content. J. L. H.

1518. *Fluid Discharges as Affected by Resistance to Flow.* **W. J. Walker.** (Phil. Mag. 42. pp. 138–139, July, 1921.)—Proposes, as a possible explanation of the abnormal results noticed in the case of flow through a Venturi meter [see Abs. 765 (1921)], that during the flow, the layer of fluid next the walls, which has been shown experimentally to be at rest, may be in a state of strain, and so possess a store of resilient energy which is being continually drawn upon and replenished during the flow. Further results giving abnormal values of the coefficient are quoted.

J. W. T. W.

1519. *The Law of Gravitation and its Consequences.* **J. Le Roux.** (Comptes Rendus, 172. pp. 1467–1469, June 13, 1921.)—In connection with the interesting relationship of Schwarzschild's law of gravitation and its consequences to the logical value of the theory of relativity. Einstein's system of ten covariant equations is discussed as to the terms involved and as to the general character of the results. It is argued that, in consequence of the theory of relativity, one of the fundamental principles of classical mechanics—the "privileged" system of reference, of which the theory contests the existence, is re-established. Einstein's deductions in respect of the theory of gravitation are discussed and shown to give rise to two contradictory hypotheses. The particular conclusion in which a measuring instrument suffers a contraction in the sense of the radius vector is stated to be completely unjustified. A. B. C. L.

1520. *Theory of Relativity and the Secular Motion of the Perihelion of Mercury.* **J. Le Roux.** (Comptes Rendus, 172. pp. 1227–1230, May 17, 1921.)—The discovery of a law of gravitation capable of explaining the motion of the perihelion of Mercury has been considered a striking confirmation of the theory of relativity. Judicious criticism proves that this result has certainly been obtained *à propos* of the theory of relativity, but that it is not a consequence of it, nor is it even an argument in its favour. Einstein seeks to establish the equations of motion of a point by the consideration of a quadratic form of differentials with four variables. The fourth variable is called "time" but this "pseudo time," in general, is common only in name with the ordinary time of mechanics. The forms of the Einstein equations and their integration by Schwarzschild are discussed, and a method of integration is given for which greater simplicity and rapidity are claimed. The solution arrived at is discussed critically. A. B. C. L.

1521. *Gravitation.* **Q. Majorana.** (Accad. Lincei, Atti. 29. i. pp. 23–32, Jan. 18; 90–99, Feb. 1; 163–169, March 7; and pp. 235–240, March 21, 1920.)—Elaborately careful measurements show that there is an absorption of gravitational force by intervening matter, proportional to the thickness and the density of the intervening mass. From this it would follow that the true density of the sun, if assumed uniform, is about three times the density as measured astronomically. Preparations are being made for repeating the series of experiments on a large scale. A. D.

1522. *Relativity Vector Analysis.* **H. T. Flint.** (Phil. Mag. 41. pp. 389–404, March, 1921.)—The author points out that the four-dimensional analysis developed by Sommerfeld obviously bears the same relation to a more general analysis as do scalar and vector products and the theorems of Gauss and Stokes to vector or quaternion analysis. The object of the paper is to set forth this more general analysis. The notation adopted is that of Joly, the adaptability of which to relativity has been pointed out by Johnston [Abs. 218 (1920)]. After some preliminary pages of explanation of the notation, corresponding to the integral theorems of ordinary vector analysis, $\int d\rho F(\rho) = \int\int V(d\nu\nabla) \,.\, F(\rho)$ and $\int\int d\nu F(\rho) = \int\int\int \nabla F(\rho) \,.\, d\nu$, he establishes the four-dimensional analogues, together with a third, obtained by performing the operation $\Sigma d\tau(F\rho)$ through a small four-dimensional element dv, which connects a three-dimensional and a four-dimensional integral. The generalised div and curl and the operation lor (Lorentz operator) of Minkowski's calculus are also obtained. The field equations of the electron theory as expressed by Minkowski may then be considered as a generalisation of Gauss's integral of intensity over a surface, and the theory summarised in the statement that, when S is the current four-vector and lor P = S′, the normal component of the six-vector P over the surface of a three-dimensional volume is numerically equal to the amount of S within the volume, while the total tangential component vanishes over the surface, the *amount of* S signifying the numerical value of the component of S along the four-vector I$d\tau$. The four-vectors of Minkowski's calculus are limited in that they are subject to a linear transformation. The vector ρ becomes a new vector σ where $\sigma = \phi\rho$, ϕ being a linear vector operator. In the simpler case ϕ satisfies a certain cubic and here a quartic. The ratios of the four-dimensional volumes after and before the operation of ϕ are a constant. When ϕ denotes the Einstein transformations this ratio is unity. This linear transformation is analogous to that occurring in the theory of elasticity in the case of homogeneous strain, and since a further condition to be satisfied by the four-vector is that of unchanging tensor, such a transformation is analogous to a rotation. Thus the Restricted Relativity Principle may be summed up by stating that a fundamental four-dimensional medium exists which may be subjected to a homogeneous strain of type ϕ with the values of the vectors defined through the Einstein transformation, and that phenomena described by the unstrained vectors will be described by the strained vectors in exactly the same way. It is natural to generalise ϕ and give up the demand that it should be linear. The strain then becomes heterogeneous. But for small regions there is found to be still a linear relation, but true only for small changes in the neighbourhood of ρ. This appears to correspond to the "naturalness" of small regions in relativity theory. Space-time is Galilean for infinitesimal regions. In addition, $(d\sigma)^2$ is invariant, or $d\sigma^2 = d\rho^2$. G. W. DE T.

1523. *Space-Time Manifolds and Corresponding Gravitational Fields.* **W. Wilson.** (Phil. Mag. 40. pp. 703–712, Dec., 1920.)—The main subject of the paper is the determination, by the Christoffel calculus, of the equations of the geodesics in a space-time manifold in which $ds^2 = -f_1dr^2 - f_2dz^2 - f_3r^2d\phi^2 + f_4dt^2$, where the f's are functions of r only, corresponding to the gravitational field of an infinite uniform rectilinear distribution of mass. It is prefaced by a study of the simpler types of manifold: $ds^2 = -dx^2 - dy^2 - dz^2 - 2\alpha t dx dt + (1 - d^2t^2)dt^2$, $ds^2 = -dr^2 - dz^2 - r^2d\phi^2 - 2\omega r^2\phi dt + (1 - r^2\omega^2)dt^2$, $ds^2 = -\mathrm{A}dr^2 - dz^2 - r^2d\phi^2 + \mathrm{B}dt^2$, where α, ω, A, and B are constants. G. W. DE T.

1524. *Inertial Frame given by a Hyperbolic Space.* **A. McAulay.** (Phil. Mag. 41. pp. 141–143, Jan., 1921.)—The author modifies de Sitter's inertial frame to hyperbolic form by rewriting equation 51·1 of Eddington's "Report on Relativity" into $ds^2 = -\mathrm{R}^2\left\{d\Theta^2 + \sinh^2\Theta(d\theta^2 + \sin^2\theta d\phi^2)\right\} + \cosh^2\Theta dt^2$, with the corresponding changes in 51·2, 51·3, and 52·2. He then alters the scale of this three-dimensional map by writing $r = \tanh\Theta$, $\epsilon = 1$, in place of $r = \mathrm{R}\tanh\Theta, \epsilon = 1/\mathrm{R}^2$, and shows that there is then no time barrier; to a fixed observer the converse of what occurs in de Sitter's space will happen—things will seem to move uncannily fast in the distant parts of the universe and distant spiral nebulæ should show a spurious tendency to approach by a spectrum shift towards the violet. If one of two particles undisturbed by gravitation be taken as fixed at the origin and the motion of the other mapped after the manner of 52·2, it will move in an ellipse of which t/R is the eccentric angle, where t is the coordinate time, and it is shown that there will be no great difference when t is replaced by the proper time of the observer. Thus all such undisturbed particles retrace their sinusoidal motions for ever and all have the common period $2\pi R$, the speed of light being taken as unity. Moreover, every observer is the centre of all the elliptic orbits. The extraordinary nature of the results may best be seen by considering how the same moving particle will appear to two observers on a radius vector of the ellipse but on opposite sides of the curve. P and Q are two observers, say, a few metres apart, and an undisturbed particle passes between them in a direction perpendicular to PQ. They remain, say, fixed at their posts watching the particle and after many million years face each other. Then each will report to the other that the particle is immediately behind him. The paradox will disappear if Q has the minutest velocity relative to P, for then the former, if undisturbed, will rotate, in the belief of P, in the same period as does the particle. But it will remain if we suppose that a constraint bringing about relative rest is so much as possible. G. W. de T.

1525. *Arrangement of Atoms in Crystals.* **W. L. Bragg.** (Nature, 106. p. 725, Feb. 3, 1921.)—This is a reply to statements in a note published in *Nature*, Jan. 6, p. 609, alleging serious discrepancies between results given by the author [Abs. 21 (1921)] and similar figures given by Wyckoff [Abs. 1532 (1920)]. The author replies that the large differences alleged are due to errors in quoting the results given by him. With respect to the much smaller actual differences, Wyckoff's figures are expressed in a scale slightly too small and require correction in ratio 3·206 : 3·04. The original and so corrected figures are given in columns I and II of the accompanying table. The author believes Wyckoff's determination of a certain parameter (u in his paper) as 0·25 more trustworthy than his own as 0·30. This would make the author's estimate (C—O) too high, and he suggests a better value would be nearer that of F, 1·35 Å. This is the only serious discrepancy, and does not appear to the author to affect his general conclusions. The distances in the table are given in Ångström units.

	Wyckoff.		Bragg.	
	I.	II.	Experimental.	Sum of Radii.
Ca—O	2·30	2·42	2·30	2·35
C—O	1·21	1·28	1·42	1·47
Ca—C	3·04	*3·206*	*3·206*	
Mn—O	1·96	2·13	2·10	2·11
C—O	1·22	1·32	1·42	1·47
Mn—C	2·83	*3·072*	*3·072*	

G. W. de T.

1526. *Chemical Significance of the Crystal Lattice.* **A. Reis.** (Zeits. Elektrochem. 26. pp. 412–420, Oct. 1, 1920. Paper read before the

Bunsen Gesell., Halle, April, 1920.)—The author discusses the procedure for ascertaining the "natural atomic groups" in the crystal lattice and points out that, for atoms to associate to form such groups, various conditions must be satisfied. Firstly, two atomic linkings, one lying in the interior of an atomic group and the other between two atomic groups, may never be crystallographically equivalent. Secondly, the weakest of the linkings indispensable to the inner cohesion of the natural atomic group must be stronger than the strongest linking between two atomic groups. Thirdly, the natural atomic groups must be chosen so large as to allow of the fulfilment of the two preceding conditions.

Proof is advanced that for every conceivable atom lattice the definition of a natural atom group as one which obeys the above requirements is univocal. It is shown that each atom in a lattice may be surrounded by an imaginary cell by bisecting each linking distance between the atom and every adjacent atom by a perpendicular plane. Crystallographically equivalent cells represent equivalent cells and vice versa, and crystallographically equivalent linking distances correspond with equivalent cell walls.

Natural atom groups contain cells resulting from the removal of certain cell walls, these being, in the case of a binary chemical compound, the ones corresponding with the shortest linking distance between an atom and adjacent atoms.

With a few exceptions crystal lattices may be classified as follows:

	Polyatomic Groups.	Monatomic Groups.
Similar atomic groups	Molecule lattice	Monatomic lattice
Dissimilar atomic groups....	Radical-ion lattice	Atom-ion lattice

For di- and tri-atomic gases the distances between the nuclei are probably between 1 and 1·5 Ångström units. All strong intramolecular linkings correspond with distances of 1–2 Å. between the atoms, and, taking into account the magnitudes of the molecular volume, which show that in the solid state the intermolecular atomic distances are considerably greater than the intramolecular ones, it may be estimated that the former lie between 2·5 and 4 Å.

The bearings of the crystal lattice on the cohesional and thermal properties of solid substances, changes in the state of aggregation, polymorphism, the doctrine of chemical constitution, etc., are considered.

T. H. P.

1527. *Cohesion.* **H. Chatley.** (Phil. Mag. 40. pp. 213–217, Aug., 1920.)—It was pointed out by Kelvin [Roy. Soc. Edin., Proc. 4 (1862)] that if the ultimate gravitating particles of a body were sufficiently small compared with the bulk of the body, cohesion would be a necessary consequence. The author, assuming the chemical atom to be the ultimate gravitating particle, shows that if the atoms were close packed the gravitational force would be much below the value of the observed cohesive forces, and draws the conclusion that gravitational force is insufficient to be the source. He proposes the empirical cohesion formula for the mean cohesions of hypothetical atom spheres $t_2 = Gm^2/d^{2+n/h}$, where

n is between 4 and 5, t_2 is the cohesion bond, h is the ratio (>1) of mean atomic interval to that at absolute zero, while G, m, and d are as in the Newtonian formula. He mentions that in the Huangpu River he finds that fine mud resists erosion until the hydrodynamic tangential drag on a surface particle equals about 10^{-6} dyne, *i.e.*, each particle, containing some millions of molecules, is retained by at least one intermolecular cohesion bond, with the result that fine mud beds are not easily eroded, whereas coarser sand is easily moved. Also colloidal suspension and plasticity in gels becomes of importance when the weight of the particles is about equal to one inter-molecular cohesion bond, *e.g.*, with cubic particles, sp. gr. 2·5, each has a diameter $d = \left\{10^{-6}/(2\cdot5 - 1) \times 981\right\}^{1/3} = 9 \times 10^{-4}$ cm. This agrees with the dimension usually assigned as a maximum to colloidal particles. G. W. DE T.

1528. *Atomic Structure and the Periodic System of the Elements.* **R. Ladenburg.** (Zeits. Electrochem. 26. pp. 262–274, July 1, 1920. Paper read before the Bunsen Gesell., Halle, April, 1920.)—A general review of the subject to date. The paper contains an appendix of 40 references and short notes. A. B. W.

1529. *The Weather Factor in Aeronautics.* **C. L. Meisinger.** (Monthly Weather Review, 43. pp. 701–708, December, 1920.)—The experience of European commercial aerial transport enterprises has indicated that the development of this form of transportation will naturally evolve a field for the aeronautical meteorologist, whose work will consist essentially in reducing for the benefit of his organisation the detailed information for the individual pilots, a function too complex for any governmental agency to handle.

A specific example of the effect of winds on flight is given which indicates the lines along which meteorological information may be organised. In this connection, one research problem of profound importance is that of the reduction of barometric pressure to levels in the free air. The success of this problem is largely dependent upon the amount of upper-air observations collected. L. H. W.

1530. *Law of the Geoidal Slope and Fallacies in Dynamical Meteorology.* **C. F. Marvin.** (Monthly Weather Rev., 48. pp. 565–582, Oct., 1920.)—The action of gravity upon bodies moving over a rotating globe is expressed in two wholly independent inertia reactions. One of these has long been known and dignified by a specific title, *the law of equal areas*. Its action in the dynamics of the atmosphere has been fully discussed by practically all writers on the subject. The other reaction has also long been known, but strangely enough has never been christened. Nameless and neglected, the important part it plays in controlling the motions of the air has been overlooked and misunderstood, or even ascribed to friction and other actions. The present paper aims to clear away these mistakes and proposes that the neglected principle be dignified by the name of *the law of the geoidal slope*. The two actions are inseparable, simultaneous in their operation, not directly antagonistic, but coordinate and complementary. Their action on a body in frictionless motion on a rotating globe is analysed and made clear. The general motions of the atmosphere are briefly discussed as steady motions under forces balanced against resistances, and the principal equations of motion are given for cyclonic, anticyclonic, and parallel systems of isobars, including a table of gradient winds for different latitudes and conditions. The crucial question at issue is submitted to be: What is the nature of the frictionless circulation of the air of a polar hemisphere assumed to be warm at the equator and cold at the poles? A rational answer to this question is offered in which the irreconcilable differences between the frictionless polar cyclone of the mathematicians and a rational polar cyclone derived from the equations of the gradient winds are clearly exhibited. AUTHOR.

1531. *Anemometric Tests with the Kata-thermometer.* **L. H. Nichols.** (Roy. Soc. Canada, Trans. 14. Sect. 3. pp. 7–9, 1921.—Summary.)—The object of the work is to test Hill's kata-thermometer under outdoor conditions. The method adopted is to compare the wind speed deduced from dry kata-thermometer readings, according to the theory of the instrument, with the mean given by several standard anemometers. The speeds so obtained have exceeded the anemometer value by as much as 60 %. Detailed analysis of the results shows that gustiness and radiation both have marked effects on the kata readings outdoors.

Further experiments have been carried out, in which the dry kata-thermometer has been exposed both in air under controlled convection and radiation conditions, and also *in vacuo*, and work is in progress on the formulation of corrections to take account of disturbances due to gustiness and radiation. M. A. C.

1532. *An Approximate Seven-Year Period in Terrestrial Weather with Solar Correlation.* **H. W. Clough.** (Monthly Weather Review, 48. pp. 593–596, Oct., 1920.)—Investigators of the relation between terrestrial weather and solar activity have generally agreed that high temperature is associated with a minimum of sun spots in the 11-year period, and vice versa. This relation is most clearly defined in the Tropics, but with increase of latitude the amplitude decreases, and there is a tendency to the formation of a secondary crest, which approaches in amplitude that of the primary crest. A seven- or eight-year period has been independently noted by many investigators in the variations of temperature, pressure, and precipitation. The author presents data and curves for the United States showing the persistence of a period in weather averaging 7 years from 1790 to 1919. The length of this period varies systematically and periodically over an extreme range of 4 or 5 years in a cycle of about 25 to 30 years. These variations synchronise closely with similar variations in the length of the 11-year sun-spot period. The combination of the 7-year and the 11-year periods results in the subordinate crests found in the curve of the 11-year variation in temperature, and probably accounts for the period averaging 21 or 22 years noted by many investigators. AUTHOR.

1533. *The Making of Upper-Air Pressure Maps from Observed Wind Velocities.* **C. L. Meisinger.** (Monthly Weather Review, 43. pp. 697–701, Dec., 1920.)

1534. *Relation of Prolonged Tropical Droughts to Sun-Spots.* **W. H. Pickering.** (Monthly Weather Review, 48. pp. 589–592, Oct., 1920.)—

A study of the collected rainfall data covering the last 50 years in the island of Jamaica has shown that there have been 12 droughts, 9 of which have followed closely after a sun-spot maximum or minimum. It appears that droughts occurring after the maxima show a greater deficiency of rainfall, and last longer, than those occurring after the minima. On the basis of sun-spot data a drought, predicted in March 1919, to begin during 1919 or 1920, actually began in June, 1919, and was continuing at the time of writing the paper. It is suggested that the cause of the variations of rainfall may lie in the effect of changes in ocean temperatures on condensation and evaporation in the Tropics, and the increased solar magnetic activity after sun-spot maxima, although the reason for such a solar relation is not apparent. The effects of volcanic dust on radiation may also be a factor. AUTHOR.

1535. *Seismograms.* **S. Banerji.** (Calcutta Math. Soc., Bull. 11. pp. 239–254, March, 1921.)—This paper is a useful summary of the interpretation of seismograms, and includes the results of much modern work on the propagation, surface reflection, and energy of earthquake waves. W. A. R.

1536. *Changes in Lunar Craters.* **W. H. M. Christie.** (Roy. Astron. Soc., M.N. 81. pp. 451–453, April, 1921.)—Drawings made of the craters Aristillus and Eratosthenes, at Pickering's telescope at Harvard College Observatory, Mandeville, Jamaica, are here reproduced with a short account of the changes there shown and a few notes on parallel observations by Pickering. W. W. B.

1537. *Newton-Einstein Planetary Orbit.* **G. Greenhill.** (Phil. Mag. 41. pp. 143–148, Jan., 1921.)—The author states as his object the standardisation of the transformation of the Newtonian Problem of Two Bodies into the Einstein form and close examination of the units employed. By direct integration of the Einstein equation to the orbit he shows that the change from Newton's ellipse into Einstein's orbit is from $1/\mathrm{SP} = \cos^2\tfrac{1}{2}\theta/\mathrm{SA} + \sin^2\tfrac{1}{2}\theta/\mathrm{SA}'$ into $1/\mathrm{SP} = \mathrm{C}n^2\tfrac{1}{2}p\theta/\mathrm{SA} + \mathrm{S}n^2\tfrac{1}{2}p\theta/\mathrm{SA}'$.

He also discusses some special cases and compares with Einstein's equation, equations derived from Newton's by adding terms proportional to U^3 and to u^5. He also invites Einstein relativists to justify the measurement of mass in terms of length, which is an essential element of Einstein's theory. G. W. DE T.

1538. *Displacement of Star Images near that of the Sun.* **E. Lihotsky.** (Phys. Zeits. 22. pp. 69–71, Feb. 1, 1921.)—The author calculates, on the Newtonian gravitation law, the total deflection by the sun's gravitation of a particle starting from infinity with the velocity of light, passing near the sun's surface away to infinity, and finds that, in spite of the difference between the Newtonian and Einstein gravitation potentials, this total Newtonian deflection of the particle is equal to the Einstein deflection of a light-ray having its nearest distance from the sun equal to that of the particle. The distribution of the curvatures along the two paths is, however, very different. At their similar minimum distances from the sun, the Einstein curvature of the ray is half the Newtonian curvature of the particle, while at an infinite distance from the sun the former is double the latter. Since in the eclipse observations the measurement obtained was that of the total deflection, the author concludes that the observed deflection of the ray would be the same whether the gravitation law was that of Newton or of Einstein, so that such observations cannot provide a criterion for distinguishing either law as preferable to the other. G. W. DE T.

1539. *On the Pressure in the Atmospheres of the Stars.* **P. Salet.** (Astrophys. J. 53. pp. 327–328, May, 1921.)—*Pressure in the Atmospheres of Arcturus and Procyon.*—A comparison of radial-velocity measurements of lines known to show large pressure-shifts with those of other lines seems to indicate pressures of, respectively, about 3 and 2 times that of the sun in the atmospheres of these two stars. However, it is not certain that the small positive shifts observed are due to prsesure. AUTHOR

1540. *Suspected Variable, Bond 624, in Trapezium of Orion.* **J. A. Parkhurst.** (Astrophys. J. 53. pp. 317–322, May, 1921.)—*Variability of Bond 624 in Orion.*—The photo-visual magnitudes obtained from 67 plates covering the past 16 years have been arranged in order of phase according to Hartwig's elements, but no periodic variation from the mean, 8·32 mag., is shown and the average deviation of the normal point is only 0·06 mag. The comparison stars used gave excellent standards for the detection of any variation, even slight. Evidently the elements given by Hartwig cannot be correct.

Photo-visual Magnitudes of seven stars in Orion, Bond 619, 628, 640, 685, 708, 734, and 741 are given and compared with Graff's values. AUTHOR.

1541. *Great Velocities of Planetary Nebulæ.* **A. C. Gifford.** (New Zealand J. of Sci. 4. pp. 9–12, March, 1921.)—The difficulty of fitting in the planetary nebulæ with their high velocities (average more than double that of stars) can be surmounted, according to the author, on the hypothesis that they are " third bodies " formed by grazing collisions. He works out the expected resultant velocity of the " third body " under varying relations between masses of colliding bodies, and obtains a range of values whose mean agrees quite well with the tabulated mean velocity of measured planetary nebulæ. W. W. B.

1542. *Cepheid Variation.* **C. D. Perrine.** (Roy. Astron. Soc., M.N. 81. pp. 442–448, April, 1921.)—In a paper [see Abs. 1058 (1920)] Plummer has criticised a conclusion of the author [see Abs. 66 and 67 (1920)]. This criticism the author acknowledges as just, inasmuch as the residual radial velocities of the Cepheids do not constitute a test of the pulsation hypothesis. He maintains, however, that a source of energy to maintain pulsations or fluctuations may exist in the form of cosmic matter in galactic regions. The velocity curves of the Cepheids, though not all perfectly represented by orbital motion, are shown sufficiently well to admit orbital motion as a satisfactory explanation. Evidence that relative mass of components governs orbital eccentricity is found in visual and spectroscopic binaries and in the solar system. Cepheids seem also to conform to this rule, which therefore supports a binary hypothesis. Light-variations of Cepheids do not accord with changes of volume demanded by the pulsation hypothesis, so far as we can understand the process. If cosmical matter is added to a star's atmosphere, it is expected that the absorbing or reversing layer would be thinnest at maximum of light, which agrees with the spectrum lines of δ Cephei. And finally, if the cluster variables are true Cepheids, their restricted preference as to distribution does not contradict the hypothesis that their variation is chiefly due to an external cause. W. W. B.

1543. *Initial Radiation from a Nova.* **A. C. Gifford.** (New Zealand J. of Sci. 4. pp. 6–9, March, 1921.)—The author apparently assumes that a nova is a third body resulting from a collision between two stars, and having an initial temperature of several million centrigrade degrees. By Wien's displacement law he traces the approximate wave-length of the rays of max. energy for different temperatures from 500° C. (red just visible) to 30,000,000°; these ranging from 37,516 to 1 in Å. units. He infers that for sunlight alone of ordinary light-sources is the maximum in the visible spectrum. Even a white-hot body has its waves of max. energy far down in the infra-red, while for all temperatures over 7500° the maximum is in the ultra-violet. He thus finds that at first the nova radiates energy in very short waves of the order of X-rays, so that from a very high observing station it might just possibly be detected by electrical means before the visible outburst. He next applies Stefan's law to show that the initial output of radiation should be a million million times as great as the solar if the nova had a volume equal to the sun and the assumed temperature of 6,000,000°. Such a process could only last a very short time. Carrying the idea a stage further, he considers the ratio of the energy of the nova to that of the sun, and concludes that in the early stage the nova must be very blue. He suggests that any unfamiliar blue star should be carefully watched and photographed in order to increase the chances of early observations of novæ. W. W. B.

1544. *Ultra-Violet Spectrum of Nova Aquilæ,* 1918 *June* 10. **A. L. Cortie.** (Roy. Astron. Soc., M.N. 81. pp. 438–441, April, 1921.)—In his previous papers on the subject [see Abs. 63, 548, and 1390 (1920)], the author left incomplete the separation of the two H series in the ultra-violet. The first series is broad and well defined, the second broad, furry and ill-defined. Overlapping begins between H_μ of the first series and H_λ of the second. Using for fiducial points the narrow absorption lines H and K of Ca, the author confines himself to the violet side of these lines. He resolves two series of H absorption lines, from H_ϵ to H_ω. The spectrum is mainly of α-Cygni type. The metallic lines (Fe, Si, Ti, etc.) are displaced concomitantly with the first series of H lines. W. W. B.

1545. *Note on Barnard's Observations of Nova Ophiuchi No.* 2. (*Hind,* 1848) *and of Nova Persei No.* 2 (*Anderson,* 1901). **H. H. Turner.** (Roy. Astron. Soc., M.N. 81. pp. 426–438, April, 1921.)—Barnard's observations of Nova Ophiuchi No. 2 fit well with a period of 27·3 days, or possibly 54·6 days. His observations of Nova Persei No. 2 from 1916 to 1920 have been analysed for periods from 400 days to 5 days. There is apparently a well-marked periodicity in about 396 days, but no other real period except perhaps a fluctuation in 69/11 days. A 7-day small fluctuation is attributed to the effect of regular weekly observing. The 396-day period can be probably traced back to before the 1901 outburst; but only doubtfully afterwards till 1914, when D'Esterre made some observations. W. W. B.

1546. *Map Showing Obscure Nebulæ in Relation to the Milky Way.* **J. G. Hagen.** (Roy. Astron. Soc., M.N. 81. pp. 449–451, April, 1921.)—The author adds a few words of explanation with historical notes on dark nebulæ, and draws some conclusions. He finds the entire sky outside the galactic plane covered with dense cosmic clouds, and thin nebulous veils also scattered along the galaxy itself. Sometimes quite clear sky is seen, but only around dense clusters. He also finds spiral nebulæ to abound where cosmic clouds are densest. Bright nebulæ he finds chiefly on the rim of extended clouds, rarely within them. From these conclusions he suggests that diffused nebulæ only shine by reflection from neighbouring stars; that stars were formed from these clouds, and that the Milky Way has used up most of the cosmic clouds in its region, leaving only fragmentary residues. He also suggests that this will account for the apparent avoidance of the galaxy by spiral nebulæ, since on Charlier's figures for the flattening of the galactic cluster (equatorial diameter six times polar), those round the equatorial regions would be 36 times fainter than those towards the galactic pole, and so would be too faint in general to show on a photograph. He admits objections to the idea of a permanent cavity about the galaxy; chiefly on account of the enormous measured velocities of some spirals. He suggests, therefore, a rotation of the galactic cluster itself and favours the idea that spiral nebulæ are outside and independent of the Milky Way. W. W. B.

1547. *Internal Motion in Spiral Nebula M.* 33. **A. van Maanen.** (Nat. Acad. Sci., J. 7. pp. 1–5, Jan., 1921.)—This is a contribution to the discussion as to whether spiral nebulæ are or are not external systems comparable to the galaxy. Messier 101, 81 and 51 have all shown some evidence of internal motion, and now M. 33 is added to the list. Photographs taken in 1910, 1915 and 1920 have been used and special precautions taken to avoid the effect of changing temperatures on the stereo-comparator. Thirty points are stated to be certainly connected with the nebula, and 22 others very probably so connected are marked on a chart of the nebula and the character of the motion analysed. The conclusion drawn is that the small motions indicated show a motion outwards along the arms of the spiral, an actual diameter for the nebula of about 100 light-years, and absolute magnitudes of certain points ranging up to + 1. The author considers the possibility of the nebula being an external universe, but if comparable with the galaxy the motions shown would point to an astral velocity of more than 150,000 km. per sec., which is extremely improbable, and tends to discredit the idea of an external universe. W. W. B.

LIGHT.

1548. *Notes on the Metallurgical Photomicroscope.* **J. G. H. Monypenny.** (Faraday Soc., Trans. 16. pp. 140–151, Sept., 1920.)—A paper dealing with the technique of photomicrography from the point of view of the metallographist. The chief points considered are : 1. *The illuminant and condensing system*, with special reference to critical illumination. 2. *The vertical illuminator.* It is stated that the disc illuminator is superior to the prism, particularly with high powers, but that faulty discs are more common than faulty prisms. 3. *Colour screens.* For apochromats the best results are obtained with blue screens, but with achromats a yellow-green screen generally gives the best results. 4. *Relation of aperture to magnification.* With objectives of the N.A. at present obtainable, nothing is gained by a higher magnification than 1500. 5. *Exposure and vibration effects.* In a works it is necessary to give as short an exposure as possible owing to vibration. This necessitates the use of an intense illumination. 6. *Low-power photography.* An apparatus suitable for very low magnifications (up to about 30 diameters) is described.

The paper is illustrated by photographs and diagrams. J. L. H.

o **1549.** *Transmission of Light through a Pile of Parallel Plates.* **T. Y. Baker** (Optical Soc., Trans. 22. No. 2. pp. 88–90, 1920–21.)—Finds, as the expression for the transmission through n plates, $(1-\alpha)/[1+(2n-1)]\alpha$, where α is the amount of incident light reflected at a single glass surface. The effect of absorption is neglected. J. W. T. W.

1550. *Diffusion of Light by Rain, Cloud, or Fog.* **A. Mallock.** (Roy. Soc., Proc. 96. pp. 267–272, Nov. 1, 1919.)—A brief discussion in which Q, the water-content of a cloud in volume a^3, is taken as equal to 10^{-5} and a table is given showing, for drops of sizes ranging from 0·1 to 0·001 in :—(1) the number of drops in volume a^3 requisite to halve the transmitted light ; (2) the length of a column of the cloud of section a^2 which contains n drops ; (3) the number of drops per unit volume of cloud ; and (4) the average distance between drops. It is concluded that even in the heaviest rain Q is rarely as great as 10^{-6} and has therefore been overestimated. In mist or fog, either the drops must be less than 0·001 in diam. or Q much less than 10^{-5}. L. H. W.

1551. *Double Refraction of Glass under Pressure.* **E. and [Mme.] Henriot.** (Comptes Rendus, 172. pp. 1477–1479, June 13, 1921.)—Describes the results of measurements of double refraction in prisms of crown glass under pressure and shows that the dispersion produced in this double refraction is not independent of wave-length, but that it obeys very closely Havelock's law that the expression $n\,(n'-n'')/(n^2-1)^2$ is constant, where $n'-n''$ is the dispersion produced at wave-length n. J. W. T. W.

1552. *Intensity of Light Passing through a Narrow Deep Slit.* **L. P. Sieg** and **A. T. Fant.** (Optical Soc. of America, J. 5. pp. 218–226, May, 1921.)—Describes apparatus employed for determining the effect, on the intensity of the transmitted light, of the width and depth of a narrow slit. The slit actually employed consisted of two plane steel surfaces of a pair of Hoke precision gauges, and its depth and width varied between 0·4 and 2·4 cm. and between 0·002 and 0·012 cm. respectively. The effect of variation of wave-length of the light was also investigated. A theoretical discussion of the problem is given and certain simplifying assumptions enable theoretical curves to be drawn. These agree fairly well with the observations in most cases. It is stated in conclusion that a certain width of slit must be attained before the intrinsic intensity of the transmitted light is approximately constant. In an instrument in which intensities are matched quantitatively by permitting light to pass through a slit of variable width, serious error may result if the widths be small. J. W. T. W.

1553. *Two-Lens Projection System of Variable Magnification.* **H. Erfle.** (Zeits. Instrumentenk. 41. pp. 107–116, April, 1921.)—Gives the theory and an extension of a formula found by Landolt for the separation of the lenses and their distance from the object. If the focal lengths of the two lenses be f and F, while A is the distance from the projection plane and V the magnification, then the distance from the object is equal to $a = \alpha - \sqrt{(\alpha^2 - \beta)}$, where $\alpha \equiv \frac{1}{2}f\left\{2F(V-1) + A\right\}/(f + VF)$ and $\beta \equiv f^2\left\{A + (V-1)^2F/V\right\}/(f + VF)$.

The separation of the lenses is $\left\{a(f + F) - fF(V-1)/V\right\}/(a - f)$.

J. W. T. W.

1554. *Galilean Binocular.* **T. Smith.** (Optical Soc., Trans. 22. No. 2. pp. 84–86; Disc., 87, 1920–21.)—A general description of the characteristics of the Galilean binocular, showing that with an ordinary type the objective works under much worse conditions than the eyepiece, very often at a relative aperture of f/3·5. An increase of field can be brought about by duplicating the objective and thus enabling an eye lens of shorter focal length to be used. An expression is given for the apparent field in terms of the objective diam., the distance between the centre of rotation of the eye and the second principal plane of the eye lens, and the diam. of the exit pupil.

In the *discussion,* **T. F. Conolly** said that it appeared that the design of a Galilean binocular, as regards field of view, had practically reached finality, and with this the **Author** agreed. J. W. T. W.

1555. *Elimination of Astigmatism in Use of Concave Gratings.* **P. H. van Cittert.** (Zeits. Instrumentenk. 41. pp. 116–118, April, 1921.)—The Roland concave grating gives, with the usual mounting, strongly astigmatic images, but by using a slit at infinity and observing the spectra near the normal to the grating, a completely stigmatic image is obtained. The present paper gives a description of the method of mounting a concave grating in this manner employed in the Physical Institute of Utrecht. The apparatus is mounted on a stone pillar in a space partitioned off from one of the basement rooms. The grating is carried by a steel I-girder about 2 m. long, immediately over the vertical bronze axis about which the girder can rotate. The axis is at one end of the girder and the other end is provided with a small bronze carriage, which allows that end of the girder to be moved to any required position along a bronze quadrant secured to the stone pillar. The grating is mounted so that its normal is parallel to the centre line of the girder. A lens is mounted at some position along the girder to focus the spectrum on the camera screen at the end of the girder. For work in different-order spectra the camera is inclined at different angles to the girder. The incident light passes through a slit and is reflected by a prism on to a concave mirror carried on one end of the bronze quadrant at such a distance that the slit is effectively at the focus of the mirror, from which parallel light is thus reflected on to the grating. Details are given of the dispersion, etc., realised, and photographs are reproduced of a portion of the iron spectrum obtained in the first and in the third order. A. W.

1556. *Theory of Polarisation Prisms.* VI. **H. Schulz.** (Zeits. Instrumentenk. 41. pp. 118–121, April, and pp. 144–147, May, 1921.)—In this paper the author takes the general formula previously given [Abs. 923 (1918)], and applies it to a discussion of the angle between the crystal axis and the cemented surface, and also of the magnitude of the field of view, with special reference to calcite prisms. Interesting diagrams are given showing the dependence of the above quantities on the refractive index of the material of the prism. [See also Abs. 566 (1920).] A. W.

1557. *Tracing Rays through an Optical System.* **T. Smith.** (Phys. Soc., Proc. 33. pp. 174–178, April, 1921.)—A further development, mainly mathematical, of the system described by the author in previous papers; formulæ for skew rays are put into a shape as far as possible similar to those applying to rays in one plane. AUTHOR.

1558. *Wave Propagation in Optically Heterogeneous Media. Christiansen's Experiment.* **N. K. Sethi.** (Indian Assoc. for Cultivation of Sci., Proc. 6. Pts. 3 and 4. pp. 121–141, 1921.)—This paper describes the results of a detailed study, both experimental and theoretical, which has been made of the phenomena observed in Christiansen's experiment in which the powder of a transparent substance is immersed in a mixture of carbon disulphide and benzol having a refractive index nearly equal to that of the powder. *Transmitted light.*—The range of wave-lengths transmitted by the mixture has been found to depend on the intensity of the incident light. A theoretical treatment based on the principles of the wave-theory and the theory of probability is given, and shows that the intensity of the transmitted light is given by the expression $I = e \exp - ctd\left\{(\mu - \mu')/\lambda\right\}^2$, where c is a constant which has been found roughly equal to 7, t is the thickness of the layer of powder, d the size of the particles, and μ and μ' the refractive indices of the two components of the mixture. The formula shows that with the very finest powders the range of transmission may be very considerable. *Colours of the halo.*—The statement made hitherto that the colour of the halo is complementary to that of the transmitted light is not correct. The halo is not of one colour throughout, but has a definite structure. This is shown by observations and photographs of the spectrum of the halo, which at small obliquities consists of two narrow bright bands separated by a dark interval; these bands widen out as the angle of observation is increased. The facts are explained by observations in monochromatic light which indicate that the distribution of intensity in the halo may be taken to be of the form $e \exp - bx^2/(\mu - \mu')^2$, where b increases as the size of the particles is increased and as the thickness of the layer or the wave-length of light is diminished. *Surface colours.*—The level surface of separation between the clear liquid on the top and the powder below exhibits brilliant colours which are not only different at different stages of the mixture as regards the reflective indices, but are also different on the two sides of the boundary. This effect does not appear to have been noticed before. Presumably it is due to total reflection effects at the boundary. *Liquid mixtures.*—A mixture of glycerine and turpentine shows similar phenomena, but these become evident only when the flask containing the mixture is heated by immersion in hot water. At ordinary temperatures there is no light transmitted. The halo in this case is, however, much smaller, but the general transparency of the mixture is very great. Some interesting diffraction effects by the edges of the liquid drops were observed.

Colours of doubly-refracting powders.—Doubly-refracting powders, such as quartz, are, contrary to the statement of R. W. Wood, unsuitable for the exhibition of the true Christiansen phenomenon, because in their case there is no regularly transmitted light. The whole of the light emerging through the powder appears in the halo, which is differently coloured in parts. There is a particular wave-length for which the size of the halo is a minimum, and this has been shown both theoretically and experimentally to correspond to the case in which the refractive index of the liquid is equal to $\frac{1}{2}\left\{\mu_0 + \frac{1}{2}(\mu_0 + \mu_e)\right\}$, where μ_0 and μ_e are respectively the refractive indices for the ordinary and extraordinary rays. A. W.

1559. *Optical Effects of Light Scattering by Electrons.* **J. J. Thomson.** (Phil. Mag. 40. pp. 713–734, Dec., 1920.)—The author first considers the radiation along the x-axis emitted by the electrons, all supposed to move in the same way at the same instant, in a thin slab bounded by planes perpendicular to this axis, and shows analytically that if the electrons acquire from the primary wave a finite average velocity in any direction, secondary waves with the electric force in that direction will be emitted. Hence the mixture of primary and of secondary waves will differ in polarisation from the primary light unless the primary electron displacements are in the direction of the electric force. In the latter case we may take $m(\ddot{x} + n^2x) = ef$ as equation of motion of an electron, and if $f \propto \epsilon^{ipt}$, $x = ef/m(n^2 - p^2)$, where n is the frequency of the electron, which leads to Lorentz's equation $\mu = 1 + 2\pi e^2\sigma/m(n^2 - p^2)$, where μ is the refractive index and σ the density of the electrons. If the frequency varies it will follow that, if σ_s be the density of electrons with frequency n_s, $\mu = 1 + 2\pi e^2/m \,.\, \Sigma\sigma_s/(n_s^2 - p^2)$. If an atom be so constituted that the displacement of an electron is not in general in the direction of the electric force, there will be three directions fixed in the atom such that a force along one of them produces a displacement in the same direction, giving rise to three equations of motion of the same type as before, in which n and f will have the values $n_1, f_1, n_2, f_2, n_3, f_3$ respectively, and Lorentz's equation will become

$$\mu = 1 + 2\pi e^2\sigma/3m \,.\, \left\{1/(n_1^2 - p^2) + 1/(n_2^2 - p^2) + 1/(n_3^2 - p_2)\right\}$$

in the case of uniform orientation of the atoms. It is easily seen that the mixed light may differ from the primary by becoming elliptically polarised or may merely have its original plane of polarisation rotated. If the electrons in a slab of thickness D all have the same intrinsic frequency and are exposed to a magnetic field H parallel to the direction of propagation of the light, the rotation is found to be $pe/2cm \, . \, d\mu/dp \, .$ HD, where c is the velocity of light. If n be large compared with p, the rotation will be proportional to the square of the frequency, which is a rough approximation to the truth in a considerable number of cases. The rotation by such substances as quartz or sugar solution cannot be explained by consideration of the behaviour of isolated electrons in an atom, but it is shown analytically that it can be accounted for by a system of electrons held so firmly in position that they act somewhat as a rigid body, a force acting on one electron displacing the whole system of electrons. The analysis shows that there will be rotation, in general, in the case of a crystalline arrangement, unless the molecule be *both* dynamically and electrically symmetrical, but that in a solution *either* dynamical or electrical symmetry is fatal to rotation. As instances it may be noted that if all the atoms in a molecule are in one plane, the molecule cannot when in solution give rise to optical rotation; and that a crystalline arrangement cannot do so if the centre of the electrical charges coincides with the mass-centre or if the molecule is symmetrical about an axis. Considering solutions, the question arises whether on any reasonable supposition as to the values of the quantities involved, the expressions obtained would give values for the rotation of the same order as those observed for optically active surfaces. The conclusion is that if the whole molecule be supposed to rotate as a rigid body under the electric forces in the wave of light, the movement produced will be insufficient to account for the rotation produced by optically active substances. The author suggests, however, that the molecule may be regarded as made up of two parts consisting, respectively, of the atoms in the molecule, and the electrons which bind them together, and that when the light waves fall upon the molecule, in consequence of the relatively enormous mass of the atoms, the displacement of the atomic system will be insignificant, but the much lighter electron system may be expected to undergo much greater rotation. The motion of the electrons consequent upon this rotation is what, in his view, gives rise to the rotation of the plane of polarisation. It is to the electron system, therefore, that the author's analysis must be applied. The objection might here be raised that since the electrons are all of the same mass, and the electrical centre of the system coincides with the mass centre, the analysis shows that the system would be too far symmetrical to give rise to optical rotation. It is invalidated, however, in virtue of the restoring forces called into action by the several electron displacements. If these forces are different for the different electrons, the system may become so unsymmetrical as to become capable of causing the rotation. This is illustrated by the detailed consideration of a simple case. Displacements of this kind will explain the interesting fact that optical rotation of a solution of an active substance may depend, not merely in magnitude but also in sign, on the nature of the solvent. If we had a theory giving the configuration of the molecule and the periods of vibration of the electrons, we could calculate by the expressions here developed, the value of the molecular rotation. The configuration and periods enter into these expressions in so complex a manner that the periods are not easily calculated from the rotation. Thus observations on the optical rotation are more likely to be useful as a test of any theory of the configuration and structure of the molecule than as a means of discovering this structure.

G. W. DE T.

1560. *Geometrical Optics and Einstein's General Relativity Theorem.* **T. Levi-Civita.** (Riv. Ottica e Meccan. 1. pp. 187–200, July–Dec., 1920.)—A quasi-popular mathematical discussion explaining the relation between the deflection 0″·88 to be expected on ordinary principles if the rays of light passing the sun can be regarded as having inertia in virtue of their velocity ($\delta m = \delta(\text{Energy})/c^2$) and Einstein's predicted value 1″·76.
A. D.

1561. *Michelson and Morley's Experiment.* **A. Righi.** (N. Cimento, 21. pp. 187–208, Feb.–March, 1921.)—An unfinished paper, interrupted by the author's death, being the fourth of a series [Abs. 1498 (1919) and 1169 (1920)], and intended to lead to a crucial experiment as to the validity of the theory of relativity.
A. D.

1562. *Structure of the Photographic Image.* **C. E. K. Mees.** (Eastman Kodak Co.'s Research Lab., Comm. No. 109. Frank. Inst., J. 191. pp. 631–650, May, 1921.)—The first part of the paper deals with the unexposed emulsion, and the present state of our knowledge with regard to the unexposed silver bromide grains is summarised as follows: They are crystals belonging to the regular system showing strain, containing in most emulsions some iodide as well as bromide, and probably containing, absorbed in them, other substances such as soluble bromide, gelatine, etc. Their sizes are determined during the precipitation of the emulsion, and are distributed over a range of diameters varying from ultra-microscopic grains below $1/10\mu$ in diam. to occasional grains as large as 10μ in diam. The curve relating the sizes of grains to the number of each size present in an emulsion can be measured, and is probably related closely to the characteristic curve of the emulsion expressing the relation of density to exposure and therefore the photographic properties of the emulsion as a whole. Grains of the same size may vary in sensitiveness, and the sensitiveness of grains of different sizes in the same emulsion may vary from group to group. It can be shown that a geometrical relation between the sensitiveness of grains of different sizes is sufficient to account for the photographic properties displayed by emulsions prepared in different ways. In the developed image the silver bromide of each exposed grain is transformed by development into an equivalent mass of silver. The question whether the effective area of the developed silver grain is the same as, or greater than, the area of the silver halide grain from which it is formed is under investigation; it is probable that the effective areas are substantially the same. Experiment shows that to a high degree of approximation the amount of silver present in a photographic plate per unit area is proportional to the optical density, which is measured as the log. of the opacity, the opacity being the inverse of the transparency. The question arises as to how far the photometric constant is dependent upon the size of the grains of developed silver and as to whether it is altogether independent of their distribution in the film. These problems have not yet been settled experimentally. The graininess and sharpness of the image are also considered. Measurements bear out the conclusion that the resolving power of an emulsion is the product of the three factors—graininess, turbidity, and contrast, all three factors playing a part in the determination of the resolving power as observed, and thus giving a very complex relation between the size of grain, the wave-length, and the effective resolving power, while the practical resolving power obtained, like the sharpness of an edge, is affected by the diffusion phenomena of development which at the present time are very imperfectly understood. A. E. G.

1563. *Sensitometric Study of the Reduction of Developing-out Papers.* **L. A. Jones and C. E. Fawkes.** (Frank. Inst., J. 191. pp. 503–516, April, 1921.)—Since the quality of the photographic print may in some cases be improved by the proper reduction of density, it seemed advisable to investigate the effect of various reducers when used for this purpose. The problem is considered in this paper entirely from the sensitometric standpoint, very little attention being paid to the theory of the action of these reducers on the deposits, and all conclusions relative to the merit of the various reducers tried are based upon the consideration of the sensitometric curves rather than upon actual prints. From a consideration of the shape of the characteristic curves of various papers it can be seen that in order to improve the quality of the print, a reduction of density should be in some cases such as to cause a decrease in contrast, while in others the reduction should increase the contrast, while a third possibility may require reduction which will reduce the density in such a way that no change in contrast is produced. No distinct line of demarcation can be drawn between these various types, since some reducers have characteristics intermediate between those represented by the typical curves. A classification is made on the basis of the character of the modifications in the characteristic curve obtained with several reducers. Thus, potassium permanganate, Bielitski's reducer, Eder's, and dichromate produce no change in contrast; iodine-cyanide and Farmer's reducer increase the contrast; while Nietz and Huse proportional reducer, and ammonium persulphate decrease the contrast. Observations are made relative to the staining of the deposit and of the gelatine resulting from the action of the reducer and its reaction products, and a means of removing the stain in most cases has been found. The character of the action of a given reducer on negatives cannot in all cases be taken as indicative of what its action on prints will be. Reducing solutions made up according to the formulæ given in the original paper have been found to give satisfactory action on printing-out papers, the particular one to be chosen in any case depending upon the modification which it is desired to make in the print. A. E. G.

1564. *Novel Magneto-Optical Effect.* **E[lihu] Thomson.** (Nature, pp. 520–522, June 23, and p. 553, June 30, 1921.)—A peculiar illumination, seen by a number of observers in the sunlit space near a resistance welder, was investigated. The luminous space was the magnetic field of a single-turn loop from a welding transformer, which carried 7000 amps., and the light from this space was distinctly polarised. The magnetic field was, generally speaking, at right angles to the line of sight and to the direction of the sunlight. The effect was diminished when the air was clear, but was enhanced on operating an iron arc near the luminous space. Tests made by special apparatus established that the orientation of the particles, or whatever causes the effect, is complete even in a weak field; also the effect is independent of the direction of magnetisation; further, the effect is minimum when the line of vision is along the lines of force. Using a Nicol prism, it was found that the polarisation was controlled by the magnetic field. The fumes arising from the arc were bluish in part and gave little effect; other fumes were yellowish grey: these were highly luminous for one position of the Nicol, but invisible for a position at right angles. Fumes and smoke from other arcs do not give the effect. The particles which cause it are extremely small, and, under a high-power microscope, appear to be less than 0·0002 mm. in diam.; they are frequently strung together, 4, 5, 6 or more in a line. Some suggestions as to the cause of polarisation are given.

In the second letter, **O. Lodge** considers that the experiments have a bearing on the old Reichenbach experiments which, although disbelieved, demonstrated genuine but capricious effects. G. E. A.

1565. *Use of a Lime Kathode of Carbon in Spectroscopy.* **Y. Sugiura** and **T. Matoba.** (Astrophys. J. 53. pp. 323–325, May, 1921.)—*Lime kathodes of carbon* may be prepared by soaking a thin hard carbon strip, such as may be cut from a telephone diaphragm, in a solution of calcium and barium nitrate and then drying it. By heating this kathode in a vacuum and applying a potential difference of a few hundred volts between it and a nearby anode, an electronic current of several amps. per cm.^{2} may be obtained which may be used for *melting small quantities of highly refractory substances* or for exciting intense light from the anode metal. *This new and powerful source of line spectra* is so intense that the structure of the spectrum lines of such metals as Cd, Bi, and Pb may be studied with an echelon grating or a Lummer-Gehrcke plate. The life of the strip was usually long enough, about 20 or 30 minutes, to outlast the anode material, which was placed in a small silica tube.

Structure of bismuth lines.—Photographs made with a Lummer-Gehrcke plate and a spectrograph show the structure of lines λλ 4722, 4308, 4122, 3596, 3511, and 3397. No measurements are given. AUTHOR.

1566. *Time-Variations in the Spectrum of an Electric Discharge.* **G. Polvani.** (N. Cimento, 20. pp. 119–184, Nov.–Dec., 1920.)—The various spectra of one and the same element may be reduced to one variable parameter, periodic variations in which are sufficient to account for the different lines, for the time-variations, and for differences of phase between the different lines. The particles are emitted under progressively different conditions at different instants of an oscillation. A. D.

1567. *Effects of a Magnetic Field on the General Spectrum.* **H. P. Waran.** (Indian Assoc. for Cultivation of Sci., Proc. 6. Pts. 3 and 4. pp. 195–198, 1921.)—A continuation of previous work [Abs. 262 (1921)]. Experiments were made with the rare gases helium, neon, etc., and their mixtures with the diatomic gases oxygen, hydrogen, etc. The effect of the magnetic field was to enhance very considerably the lines of these monatomic gases, even when they are present in a pure state. When mixed with other, diatomic gases the remarkable point is that the lines of the monatomic gases alone are considerably enhanced, while those of the diatomic gases are scarcely affected. Thus in a tube of neon and hydrogen the principal hydrogen lines are not affected at all, while the neon lines are very much enhanced. Similarly when a trace of helium is mixed with hydrogen or oxygen and the helium lines are ordinarily not visible at all, the magnetic field brings out the helium lines prominently, leaving the others scarcely affected. These results led to the natural inference by analogy, that such enhanced lines are atomic radiations, while the others may be attributed to the molecule. Thus in the case of mercury the enhanced lines λ6152 and others are probably to be classified as atomic radiations, and the unaffected lines are due to molecules. The enhancement of the argon lines noted by Kent and Frye [Abs. 1280 (1913)] is also in keeping with this explanation. Experiments with sulphur and iodine in a vacuum tube were also made, and as is to be expected from the complex conditions existing in such cases, the spectrum showed a variety of changes when subjected to the effect of the magnetic field. Further work on the subject is in progress. A. W.

1568. *Spectral Structure of the Luminescence Excited by the Hydrogen Flame.* **H. L. Howes.** (Phys. Rev. 17. pp. 469–474, April, 1921.)—*Luminescence Spectra Excited by the Hydrogen Flames.*—Calcium oxide and the Lenard and Klatt phosphorescent sulphides Nos. 3 and 13 were studied by the aid of a spectrophotometer. The broad-banded spectra were found to consist of the same components, individually overlapping and forming overlapping series of constant frequency-intervals. Series and individual components were identified with those entering into the spectral structure of these substances when excited to fluorescence by light, but the relative intensities of the bands were found to differ with the mode of excitation. AUTHOR.

1569. *Fine Structure of the Discontinuities of Absorption in X-ray Spectra.* **M. de Broglie** and **A. Dauvillier.** (Comptes Rendus, 171. pp. 626–627, Oct. 4, 1920.)—Note on certain peculiarities in the X-ray absorption spectra of elements. The fine structure of the spectra in the neighbourhood of the head of the main absorption bands is discussed. Here certain fine lines are noticed, and it is considered by the authors that careful observations of these lines for the different elements may throw some light on their chemical relations, forces of cohesion and various other phenomena which might modify the ordinary luminous spectra of these elements. A. B. W.

RADIO-ACTIVITY.

1570. *Fluctuations in Alpha-ray Emission.* **A. Muszkat** and **L. Wertenstein.** (J. de Physique et le Radium, 2. pp. 119–128, April, 1921.)—The probability fluctuations in the emission of α-particles from radio-active substances are deduced mathematically and confirmed experimentally. In the experimental work, a string galvanometer was employed to record the arrival of the α-particles emitted from a source of radio-active material. A. B. W.

1571. *Relations between Radio-active Constants.* **H. T. Wolff.** (Phys. Zeits. 22. pp. 171–173, March 15, 1921.)—The author indicates how it is possible to express the range R of α-rays as a function of the mass M (atomic weight) and the charge L (atomic number) of the nucleus in the form: $\log R = \xi \log (\frac{1}{2}M - L + K) + \eta$. The constants ξ and η are determined by the method of least squares, whilst the constant K is known within small limits. A. B. W.

HEAT.

1572. *The Heat Loss by Convection from Wires in a Stream of Air, and its Relation to the Mechanical Resistance.* **A. H. Davis.** (Phil. Mag. 41. pp. 899–908, June, 1921.)—In a former paper it was shown that Boussinesq's formula, as derived from considerations of similitude by Rayleigh [see Abs. 533 (1915)], is well borne out by some published results for the cooling of cylinders in a stream of air. The formula may be written $H/k = F(vl/\nu)$, where H is the heat lost per sec. per unit length of the cylinder of diameter l, per degree temperature excess above stream temperature, k, v, and ν being thermal conductivity, velocity, and "kinematical viscosity" respectively, of the fluid stream. Here vl/ν is the familiar variable in hydrodynamics determining fluid resistance and turbulence.

The experimental results of King [Roy. Soc., Phil. Trans., 190. p. 67 (1897)] were represented by him in the formula $H/k = B(vl/\nu)^{1/2} + C$, where B and C vary slightly with the temperature excess, and C increases with the diam. of the wire. Combining King's formula with some convection constants for air deduced on certain assumptions by Langmuir, and making allowance for the change of the physical constants B and C with temperature, a relation between log H/k and log vl/ν is obtained. Results by King, Kennelly, and Hughes for convection in air-streams of velocities ½ to 50 miles/hour, from wires of 0·003 cm. diam. up to 5 cm. piping, and for temperatures from that of boiling water to a bright red heat, are all found to lie on one smooth curve. Other experimental results by Worthington and Malone for convection of heat from a platinum wire in a stream of water are also shown to fit the same curve.

Comparing the formula $H/k = F(vl/\nu)$ with that representing the dynamic relation, $R(\rho v^2 l^2) = f(vl/\nu)$, where R is the fluid resistance per diam. length of the wire, and ρ the density of the fluid, it is evident that a relation must exist between the thermal and the dynamic effects of a fluid stream. Curves are therefore given combining values of H/k and of $R/\rho v^2 l^2$ for corresponding values of vl/ν. Plotting log H/k against log R/ρ gives practically a straight line. The simple theory advanced by Osborne Reynolds for fluid flow through a pipe, viz. $H \propto R/v$, does not hold for wires in the region considered, though there appears to be a tendency to this simple relation as the size of the cylinders is further increased. T. B.

1573. *The Current–Temperature Relation for Different Pyrometer Filaments.* **W. E. Forsythe.** (Frank. Inst. J. 191. pp. 838–839, June, 1921.)—The calibration of a disappearing-filament optical pyrometer is a determination of a relation between the temperature of the standard source and the current through the pyrometer filament when the latter is matched in brightness. For ease in reading temperatures against the standard, the current-change for a particular temperature should be as large as possible. A test of this current–temperature relation was made in the case of tungsten and carbon pyrometer filaments and the ratios of the currents were found to be very nearly the same for the temperature range from 1828° K. to 950° K. if the filaments were long enough so that the cooling due to end conductions were negligible. Hence a pyrometer lamp with a carbon filament is not superior to a tungsten lamp in openness of scale. E. G.

1574. *Internal Energy after Explosion of Coal-Gas and Air.* **W. T. David.** (Roy. Soc. Proc. 98. pp. 303–318, Jan. 3, 1921.)—The author briefly summarises the procedure and results detailed in former papers [see Abs. 1611 (1920)], and describes further experiments. By combining the results he obtains empirical formulæ by means of which the total heat loss up to the moment of max. pressure, and the rate of heat loss at any temperature during cooling may be calculated from data obtainable from the *pt* curves. In the experimental vessel the heat loss by conduction was found to be from 40 % to 60 % greater than the radiation loss. In a vessel rather more than double the size the two losses would be equal and in larger vessels the radiation loss would be the greater. He then applies the heat loss measurements to the estimation of the internal energy and the volumetric heat of the mixtures at various temperatures after explosion, and finds that at the moment of maximum pressure about 10 % of the heat of combustion of the coal-gas in each mixture has remained unconverted into thermal energy, and that after-burning continues for at least 0·25 sec. after max. pressure. The study of the internal energy values appears to throw into fair perspective the various causes responsible for the so-called "suppression of heat" in gaseous explosions—or, at any rate, in explosions of mixtures of coal-gas and air. The main theories proposed to account for the low pressures developed are: (1) Increase of specific heat of the products of combustion with temperature (Mallard and le Chatelier). Under this head may be included such dissociation as may occur, since it would naturally be included in all specific heat measurements; (2) incomplete combustion (D. Clerk); and (3) heat loss to the walls of the containing vessel (Hirn). The results here given appear to show definitely that all these are important factors, and enable a quantitative estimate to be made as to their relative importance in the various mixtures. The author estimates that the energy of combustion of the coal-gas originally in the vessel is distributed at the moment of maximum temperature as follows:—

(i) *Internal* (*thermal*) *energy:* From about 72 % of the heat of combustion of the coal-gas in a 9·7 % mixture to about 80 % in a 15 % mixture.

(ii) *Available chemical energy:* About 10 % in each mixture.

(iii) *Heat loss to walls of vessel:* From about 10 % in a 15 % mixture to about 18 % in a 9·7 % mixture. G. W. de T.

1575. *Thermodynamics and Probability.* **L. Brillouin.** (J. de Physique et le Radium, 2. pp. 65–84, March, 1921.)—The author aims at systematising and, incidentally, simplifying the main definitions and hypotheses forming the basis of the statistical treatment of thermodynamics which has now assumed preponderant importance. He shows that his definitions apply as well to discontinuous as to continuous systems and, by means of hypotheses analogous to those of Boltzmann, *demonstrates* Gibbs's formulæ for canonical systems, assumed by the latter as his starting point. The steps in solving a problem are in all cases:—Starting with the various accepted theories of internal constitution, *e.g.*, atomic, electronic, and quantic, we seek to set forth all the microscopic configurations possible with the elements assumed. From this complex we seek to find the number of possible distinct configurations corresponding to each macroscopic system determined experimentally in terms of such measurable quantities as pressure, volume, total energy, chemical composition. These foundations determine the probability-hypotheses. The absolute temperature of a body varying reversibly, *i.e.*, infinitely slowly, is defined, and the entropy of the body is defined up to a constant by the equations $dS = dQ/T = dE/T$. And the stable condition (T given) is, experimentally, the state of max. entropy, while statistically it is the state of max. probability Π. Therefore there must be a relation between T and Π, and the former being an additive quantity and the latter a multiplicative one, the relation must be $S = k \log \Pi$ (Boltzmann's formula), where k is a constant. The author takes as fundamental what Boltzmann termed the *ergodic* formula. All the microscopic states of a body, *having equal energies*, are equally probable—in preference the more general formula, omitting the words in italics, taken by Boltzmann as fundamental, as the restricted formula appears far less arbitrary. He discusses the methods employed by Kelvin and Einstein respectively for fixing the exact meaning of the probability Π_A of the occurrence of a state A, but himself prefers a simpler course. For statistically continuous systems subject to the laws of rational mechanics, Liouville's theorem shows that a uniform repartition of a group of macroscopic states amongst the possible microscopic ones will, on the average, remain uniform. In other cases it is necessary to make sure that the hypotheses introduced, regarding the passing from one microscopic state to another, are in accordance with the two states being equally probable. It then follows that the probability Π_A of a macroscopic state (of energy E) is given by $\Pi_A = P_A/N$, where P_A is the number of microscopic systems reproducing the aspect A, and N the total number of microscopic systems of energy E. Obviously then, the sum of the probabilities of all possible macroscopic states of a body of total energy E is $\Sigma P_A = 1$. Considering the equilibrium of a pair of bodies of energies E_1 and E_2, forming an isolated system, and thermodynamically normal, *i.e.*, such that ΔE between two consecutive microscopic states of either is small and that the numbers P_1 and P_2 are representable to sufficient approximations by continuous derivatives of the variables E_1 and E_2, it is shown to follow that $\partial \log P_1/\partial E_1 = \partial \log P_2/\partial E_2$. Also, from the definition of T, $\partial S_1/\partial E_1 = \partial S_2/\partial E_2$; so that $S = k \log P$, where k is a universal constant, the value of which is found to be, approximately, $1{\cdot}4 \times 10^{-16}$. Gibbs's formulæ are then obtained without any further assumptions. Further interesting illustrations and discussions will be found in the paper.

G. W. de T.

1576. *Deduction of the Dissociation-Equilibrium from the Theory of Quanta and a Calculation of the Chemical Constant Based on this.* **P. Ehrenfest** and **V. Trkal.** (K. Akad. Amsterdam, Proc. 23. 1. pp. 162–183, 1920.)—Nernst's theorem, the theory of the specific heat of solids, of the vapour-pressure and of the dissociation-equilibrium must have their common root in the general foundations of statistical mechanics and in the quantum hypothesis. Stern [Abs. 1977 (1913)] and Tetrode [Abs. 1292 (1915)] have shown how from Nernst's theorem by means of Einstein's formula for the specific heat of solids and a vapour-pressure formula for high temperatures (derived kinetically) the chemical constants (hence also the dissociation-equilibrium) may be calculated. Notwithstanding the great advantages of this method, a desire must be felt to calculate the chemical constants and the dissociation-equilibrium more directly by considering the hot gases themselves, without the use of a cycle consisting of a condensation, cooling of the crystals to the absolute zero, chemical transformation at T = 0, heating of the new crystals, and evaporation at the high temperature. Various earlier attempts in this direction by Sackur and Tetrode are described. It is not an accident that it is always the same point which remains obscure in these theories, viz. how an expression of the form N^{-N} (Sackur) or $(N!)^{-1}$ (Tetrode) can be forced into the thermodynamic probability W in order to obtain an admissible value for the entropy. The law of dependence on N can only be satisfactorily settled by utilising a process in which N changes reversibly, and then comparing the ratios of the probability with the corresponding differences of entropy. If condensation and evaporation are not to be used, and the whole process is to be carried out with gases, it will be necessary to work with a gas mixture and change the numbers of molecules of the various gases by dissociation. The following formulation of the problem is finally arrived at: By means of the quantum theory, that particular one of the various states of dissociation is determined which possesses relatively the greatest probability. On comparing the dissociation-equations arrived at in this manner with the corresponding thermodynamical equations, the same values are found for the expressions containing the chemical constants. The numerical value of the chemical constant of a molecule is found to depend not only on its mass and moment of inertia but also on the symmetry-number of the molecule. Section 1 considers fully excited and non-excited degrees of freedom. The following assumptions are made: (1) The translational motions of the molecules, as also their rotations, are considered entirely free from any limitations depending upon quanta (fully excited degrees of freedom). (2) The following motions are assumed to be absent: (*a*) the rotation of diatomic molecules about the axis of symmetry and all rotation of non-atomic molecules; (*b*) internal motions of the atoms in the molecule.

Section 2 considers the phase-space of a molecule (μ-space), and the μ-weight $[\mu]$. Section 3 investigates the constitution of the gas-mixture. Section 4 deals with the phase-space of the gas (γ-space), and the γ-weight $[\gamma]$. Section 5 investigates the expression for $\log [\gamma]$, and the entropy for an arbitrary degree of dissociation ($N_1, N_2 \ldots, N_j$). Section 6 gives a comparison of the kinetic and the thermodynamic calculations of the dissociation-equilibrium, and the resulting values of the chemical constants. Section 7 offers remarks on additional contributions of the atoms to the chemical constant of the molecule which remain indeterminate. Section 8 studies the influence on the dissociation-equilibrium of the symmetry-numbers of the molecules. Section 9 contains critical remarks on some allied deductions of the chemical constants. Additional notes are appended for the elucidation of the choice of the μ- and γ-weight. It is found that of all the original degrees of freedom only those remain in the power of h, which are not excited; the other factors are, as it were, absorbed by the integrals.

A deduction of the vapour-pressure formula for very low temperatures concludes the paper. H. H. Ho.

V.
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SOUND.

1577. *Sound of Distant Gun-Fire.* **V. Schaffers** (Nature, 109. pp. 44-45, March 10, 1921.)—Suggests that the phenomena of the long-range transit of sounds from intense sources may be explicable by diffraction. **C. J. P. Cave.** (Nature, 107. p. 140, March 31, 1921.)—Discusses the possible effects of various winds. E. H. B.

1578. *Theory of the Flute.* **G. T. Walker.** (Indian Assoc. for Cultivation of Sci., Proc. 6. Pts. 3 and 4, pp. 113-120, 1921.)—Some recent experience in designing piccolos of different bores has brought out various points in which the existing theory of the flute appears incomplete, and the present paper contains a short account of these in the hope it may stimulate a further theoretical examination of the subject. The questions at issue fall materially into the following classes: (*a*) The shape of the bore of the instrument, (*b*) position of the holes and the open end, (*c*) size of the holes, (*d*) method of blowing, and (*e*) method of fingering. Taking first the bore, Boehm pointed out that while a flute with a large internal diam. possessed facility and tone in the lowest notes the highest notes were unmanageable, and ¾ of an inch or 19 mm. is generally accepted as the standard for the ordinary D flute whose length is about 24 in. For the ordinary D piccolo a bore of ⅜ in. gives a rather feeble lowest octave and the usual 7/16-inch is better; one of ½ in. is brilliant in its lowest notes, but rather difficult in the highest. Boehm pointed out that a flute with a purely cylindrical bore cannot be in tune throughout its range, the notes of the higher octaves being flat in comparison with those of the lower. It would thus appear that the correction for the open end, or for a large hole in a cylindrical tube, increases appreciably with the frequency of the note; and this is in accordance with an observation by Bosanquet. Boehm rightly gave as the remedy for this difficulty a constriction of the bore of the upper portion of the tube (that containing the mouth hole) so that the bore diminishes gradually from its full dimensions at a quarter of the length from the top end to nine-tenths of the full dimensions at the mouth hole. The same result is apparently produced in a conical flute by making the top third cylindrical and the lower two-thirds conical, the diameter at the open end being about seven-tenths of that of the cylindrical portion.

The length of the tube to produce a given note will differ from the half of the corresponding wave-length by the sum of the corrections for the mouth-end of the flute and for the open end. Bosanquet has given corrections for open ends of 0·543 of the radius for a bore 1/30 of the wave-length and 0·635 of radius for a bore 1/12 of the wave-length. The present author, for the lowest C of a flute with a bore of ¾ in. or 1/34 of the wave-length, takes the correction for the open end as 0·53 of the radius or 0·20 in. He thence deduces from the total corrections, that the correction for the mouth-end is 1·8 in.; that for a ½-in. hole, 0·6 in.; and that for a ⅜-in. hole, 0·47 in. All these are for tube of thickness ⅛ in.; for a greater thickness the corrections would be greater.

By aid of tables the author's theories of fingering are set forth both within and beyond the usual range of the instrument. E. H. B.

1579. *Systems with Propagated Coupling.* **B. van der Pol, Jr.** (Phil. Mag. 41. pp. 826–827, May, 1921.)—Referring to a recent paper on this subject by A. W. Porter and R. E. Gibbs [see Abs. 1118 (1921)], the present author points out a slip in the algebraic sign of a coefficient which led to an unexpected conclusion.

A. W. Porter and R. E. Gibbs (*ibid.*, pp. 827–828).—The correction of sign is acknowledged, but these authors do not agree in regard to the necessity for assuming a variability in the resistance. E. H. B.

1580. *Nash Fish for Location of Submarines.* (El. Times, 59. pp. 402–403, April 28, 1921.)—Gives a description of the "Fish" due to G. H. Nash and designed for submarine locating. It is let down and towed by a ship and has two rotatable detectors. These can be turned so as to be successively in position of maximum and minimum intensity, and from these positions the direction of the submarine may be inferred. E. H. B.

1581. *Mechanical-Acoustic Efficiency of a Telephone Receiver.* **M. Wien.** (Ann. d. Physik, 62. 8. pp. 759–762, Aug. 20, 1920.)—The author discusses the criticisms of his results made by Hahnemann and Hecht [Abs. 413 (1920)], who obtained for the sensitiveness of the human ear to a tone of 1000 periods per sec. a value some 120 times as great as that previously obtained by him. He criticises the methods by which Hahnemann and Hecht examined his experimental work, and suggests that much of the discrepancy is due to a difference in definition. W. H. S.

1582. *Equations of Motion of String and Membrane, etc.* **K. Aichi.** (Phys. Math. Soc. Japan, Proc. 3. pp. 70–76, May, 1921.)—A mathematical paper in which the equations of motion of a string, a membrane, and a general elastic body are derived from Appell's principle of *énergie d'accélération.* The usual equations are obtained in each case, and it is remarked that this method of derivations is, in its main features, the same as in the case of virtual displacements. E. H. B.

1583. *Perception of Sound Direction.* **A. Pérot.** (J. de Physique et le Radium, 2. pp. 99–106, April, 1921.)—Describes by aid of a number of figures various telephonic arrangements by means of which may be repeated the intensities and phase relation of the sounds produced at each ear of an observer. The state of things which leads us to judge on which side a source of sound lies is thus analysed. E. H. B.

1584. *Meteorological Acoustics.* **W. J. Humphreys.** (Frank. Inst., J. 191. pp. 581–617, May, 1921.)—This title is used by the author (i) for the phenomena of all sounds of distinctly *meteorological origin,* such as the humming of telegraph wires, the roaring of the mountain, the rumbling of thunder, and the like; and (ii) for every *effect which meteorological conditions have* on the travel, distribution, and audibility of sounds, however arising.

The treatment, though partly mathematical, is mostly descriptive and semi-popular. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1585. *Radiation from Accelerated Electrons.* **S. R. Milner.** (Phil. Mag. 41. pp. 405–419, March, 1921.)—The author's argument calls in question the necessity of energy radiation from accelerated electrons under all circumstances as a deduction from classical electromagnetic theory. He starts with the consideration of Schott's solution [Electromagnetic Radiation, pp. 63–69] of the accelerated motion of an electron moving along the (positive) axis of x in such manner that $\xi^2 = k^2 + c^2t^2$, where ξ is its distance from the origin at time t, k is constant, and c is the speed of light. The field as given by Schott is limited by a moving boundary formed by the plane $x + ct = 0$, a transition layer (of a thickness comparable with the electronic radius) in which the electric and magnetic forces vary from the values given by Schott's equation on the right of the boundary to zero beyond it. For a point-charge it forms a layer of discontinuity, in which the lines of force emanating from the charge suddenly change their direction, and thenceforth lie in the plane. Here there is an obvious permanent loss by radiation from the system, but this irreversible radiation may be eliminated by the simple modification of taking Schott's equations for E and H as valid for all space and time, the moving boundary being dispensed with. The electromagnetic field thus expressed satisfies Maxwell's equations at every point of space and time, the equation $\operatorname{div} E = 4\pi\rho$ being satisfied in the sense that $\operatorname{div} E = 0$ everywhere except at the points $x = \pm\xi$, where it becomes infinite in such a way that $\int E_n dS$ round any closed surface surrounding the point is equal to $\pm 4\pi e$. The solution thus forms throughout all space and time an electromagnetic field which can be associated with two point-charges, $+e$ and $-e$, moving with the particular type of acceleration defined by the fundamental equation given above. There is no irreversible radiation of energy from this system; for the fields at $t = +t_1$ and $t = -t_1$ are everywhere identical, except that the sign of H is reversed. Hence, whatever outward energy flux from either charge may have occurred at $t = -t_1$, it will be exactly annulled by an equal inward flux at $t = +t_1$. The total energy of the field, being obtained by integration throughout space, except that occupied by the nucleus or charged surface of the electron, the result will depend on the shape assumed for the nucleus. Partly to avoid mathematical difficulties, partly because we cannot say *a priori* what is the exact shape to be ascribed to the nucleus, the theory of the Lorentz spheroid applying strictly to uniform motion only, the author assumes a shape coinciding with the latter when the acceleration vanishes, and when the radius of the electron is indefinitely small, and obtains for the field energy of either charge in the region external to the surface an expression identical with the field energy of a Lorentz electron of the same e and radius a in uniform motion with the same velocity. But for the present a is assumed infinitesimal, so that the surface becomes identical with a Lorentz spheroid. This makes the energy and momentum formally infinite, but they are definitely evaluated in the limit, and the essential feature of the solution, the absence of radiation from the system, is not affected by the assumption. To make the electromagnetic and mechanical schemes agree, the nucleus, like that of the uniformly moving electron, must be supposed to possess the internal energy $e^2(1-\beta^2)^{1/2}/6a$, and the total energy of each electron in the system becomes $w = 2e^2(1-\beta^2)^{-1/2}/3a$, where $\beta = \dot{\xi}/c$. By making the surface of the electron a slightly different one from the former, but agreeing with it when a is infinitesimal, the x-momentum associated with the positive electron external to this surface is found to be $g = 2e^2\beta(1-\beta^2)^{-1/2}/3ac$, as for a Lorentz electron. This solution, as it stands, is an example of what the author calls fictitious solutions of Maxwell's equations, as obviously it does not fulfil the condition of conservation, etc., and cannot therefore be accepted as an actually possible motion, but a conservative system may be derived from it by superposing upon the field a uniform electric field X of infinite extent, and parallel to the x-axis so chosen as to produce, on the basis of Lorentz's equation, the actual motion which the electrons possess. The equation so obtained represents a system of two electrons of opposite sign and Lorentz mass moving in a prescribed way in a uniform electric field. It is then shown that, although the total energy of the system is infinite, it can be proved conservative by considering the flux of energy in the field. This flux can occur only across the boundaries, and is not necessarily zero for a conservative system. Even in the case of the uniformly moving electron, considerations of the continuity of the flux, dealt with in a previous paper [Abs. 288 (1921)], as well as those based on dynamics and relativity [Lorentz, Theory of Electrons, § 180], necessitate the postulation of a definite store of internal energy, of the amount given above, within the nuclear boundary. The net energy flux outwards across the boundaries must equal the net rate of decrease of the internal energies of the electrons. This is shown to be the case, and also that w and g fit into a mechanical scheme. In fact it formally satisfies the Lorentz equation $F = \rho(E + [vH]/c)$, where $F = Xe$. In two respects the solution still remains unreal :—(1) It is a limiting case in which the electrons have shrunk to a point, and move in a correspondingly infinite field. (2) Extending over all space and time, it does not represent the initiation of the motion, and does not correspond substantially with a practical case, *e.g.*, when an electron, passing through a hole in a charged plate, enters an ultimately uniform field. But, the author observes, (1) clearly does not affect the radiation; and with regard to (2), electromagnetic solutions, like those of other differential equations, represent only steady states under idealised conditions, and without reference to the manner of their initiation.

The author then discusses the proof of the presence of radiation as necessarily accompanying the accelerated motion of charges, especially in its application to Schott's solution. The proof is based on the solution in terms of retarded potentials for the field of a point-charge in a prescribed state of motion, and the author infers that the limitation of the solution by a moving boundary appears involved, and the unlimited solution here discussed raises the question whether the boundary is essential in every case for the representation of real motions. The arbitrary motion discussed in the proof makes the case considered fictitious in the sense discussed above, showing that an additional conception is involved in the complete proof, which must necessarily concern itself with a charge set in motion by an electromagnetic field. Lorentz's equation is applied, and interpreted by assuming the electron to move as if it were a particle of given mass acted on by determinate mechanical force. The retarded potential solution corresponding to the resulting motion of the charge, superposed on the external field which gives the motion, then forms the complete solution, and the boundary remains. The necessity of the boundary arises from the conception that the charges or nuclei are set in motion by the field in their vicinity, and that the resulting changes are *actually* propagated outwards from them. This *actuality* is not involved in the mathematics, and the author claims that from first principles it is equally logical to consider the motion of the charges and the changes in the field to be two connected aspects of a single solution as to suppose that one is antecedent to the other. The former point of view would not affect the character of the field of being expressible in terms of retarded potentials, but it would permit other boundary conditions than those of a simple moving boundary to be applicable for the representation of real motions. The case discussed in this paper seems to show the legitimacy of a solution with less prescribed boundary conditions. G. W. DE T.

1586. *Electrification of Mercury by Friction.* **E. Perucca.** (N. Cimento, 21. pp. 275–301, April–May–June, 1921.)—A continuation of the work recently recorded [see Abs. 912 (1921)]. In the present paper, after describing the experimental conditions, the following points are dealt with: The time-charge curve in free air; cause of the phenomenon; amalgams; variations in the insulator; and the tribo-electric effect compared with the Volta-effect [see also Abs. 1637 (1920)]. A. E. G.

1587. *Electromagnetic Radiation Theory.* **H. Bateman.** (Phil. Mag. 41. pp. 107–113, Jan., 1921.)—The author sets forth in compact form the analysis he has developed for his speculations regarding the electrical nature of the ether as being of the kind required for the discussion of the suggestions made by J. J. Thomson [Abs. 676 (1916)] and L. Page [Abs. 1185 (1920)] with regard to the nature of radiation. Considering an electromagnetic field of suitable type, he finds fairly reasonable ground for the assumption of Page's type of radiant field allowing for rotation. He also obtains results which may be taken as exemplifying the guiding lines of force of which Thomson speaks. The possibility of radiation in quanta is also established. He considers it hard to understand why the electron should turn completely round a finite number of times while emitting radiation. A further difficulty is that when an electron rotates *and* revolves, different lines of force generally revolve at different rates, and there may be one only whose angular velocity corresponds with the frequency of the light, while to make them all revolve with the same angular velocity would apparently involve the impossibility of a non-radiating orbit. He considers that, according to the theory in question, the suggestion that all electromagnetic fields occurring in nature can be built up from the fields of electric poles travelling with velocities less than c is untenable: that, in fact, it seems almost necessary to adopt a more general type of field as fundamental, and suggests the possibility that the simple radiant fields described by himself may prove to be the most suitable. G. W. DE T.

1588. *Electromagnetic Energy and Thermodynamic Potential of a Current System.* **A. Liénard.** (Comptes Rendus, 172. pp. 208–210, Jan. 24, and pp. 323–325, Feb. 7, 1921.)—Let U be the internal energy of a system consisting of currents $i_1, i_2 \ldots$ and magnetic bodies, dW the work done thereby, dQ the heat evolved, and $\phi_1, \phi_2 \ldots$ the resulting fluxes in the several circuits, then $dW + dQ + dU = \Sigma i d\phi$. In the absence of hysteresis $dQ = -\Sigma T dS$, T being the absolute temperature and S the entropy of a region of uniform temperature. Then $dW + \Sigma S dT + \Sigma \phi di$ is easily seen to be a perfect differential, and writing $H = U - \Sigma TS - \Sigma i\phi$ and assuming the variables normal in the thermodynamic sense, it follows that, where $d_{T,i}$ signifies differention with T and i constant, $dW = -d_{T,i}H$, $S = -\partial H/\partial T$, $\phi_1 = -dH/di_1$, etc. The thermodynamic potential H is then generally $H = -\Sigma[0, i]\int \phi di + F(T, x, y, \ldots)$, the variables of the second term being taken as constant in the integration and F being the thermodynamic potential in the absence of currents. Considering phenomena of electromagnetic origin only, F may therefore be neglected in evaluating W and S, and $U = H - T\partial H/\partial T - \Sigma i \partial H/\partial i$. For a single circuit of inductance L with magnetic bodies of constant permeability only, this becomes $U = (L + T\partial L/\partial T)i^2/2$. The author points out that the formula has been given as $U = (L - T\partial L/\partial T)i^2/2$ [Comptes Rendus, 127. p. 507 (1898)], but obtained on assumptions which are mutually contradictory except when $i = 0$. He also develops further formulæ applicable to isotropic bodies of constant permeability, and indicates extensions to aeolotropic bodies of variable permeability.

F. Michaud. (Comptes Rendus, 172. pp. 586–588, March 7, and pp. 748–750, March 21, 1921.)—Liénard's method of separating out the electromagnetic actions and evaluating them independently is arbitrary, and seems wanting in exactitude, especially in complex cases, *e.g.*, where the dimensions of the circuits vary with temperature, or where the permeability of the medium varies with pressure. Michaud summarises a method which he has developed in detail in a recent volume [Énergétique générale], which enables the complete system of equations of the energetics of a reversible system to be established. The most interesting of these are not those which determine the internal energy, the different energy potentials, and the integral energy, none of which are of direct experimental significance, but those which give by their variations the separate components of the different energetic terms. The latter can all be written down directly without calculations by means of mnemonic rules which the author has developed, and some of which he reproduces here. They separate naturally into two groups, the first being of the Clapeyron type, while the second he designates as of generalised Reech type, in that they reduce to Reech's equation in the case of a gas considered as a thermo-elastic system. As an example of the latter, consider two fixed circuits in a medium of constant temperature and pressure. Then $(\partial\phi_1/\partial i_1)_{\phi_2}(\partial\phi_2/\partial i_2)_{i_1} = (\partial\phi_2/\partial i_2)_{\phi_1}(\partial\phi_1/\partial i_1)_{i_2}$, showing that the ratio of the self-inductances is equal to the flux variations taken, for each circuit, with a constant flux through the other. Or again, take a single circuit in a medium of constant volume or constant pressure. Here $(\partial\phi/\partial i)_S(\partial S/\partial T)_i = (\partial S/\partial T)_\phi(\partial\phi/\partial i)_T$, showing that the ratio of the heat capacities for constant current and for constant flux is equal to that of the isothermal and isentropic inductances. As examples of the former group, if X and x represent respectively the forces between two circuits and their displacements, the forces are given by equations of the form $(-dX/\partial i_1)_{x, P, T, x_1 \ldots, i_2 \ldots} = (\partial\phi_1/\partial x)_{i_1, P, T, x_1 \ldots, i_2 \ldots}$. The correlation between magnetism and temperature is given by equations of the form $(\partial\phi_1/\partial T)_{i_1, P, x, x_1 \ldots, i_2 \ldots} = (\partial S/\partial i_1) : {}_{T, P, x, x_1 \ldots, i_2 \ldots}$. A field increase will cause heat absorption if the permeability is greater when hot than when cold, and vice versa. The reciprocal effects of magnetisation and pressure are given by equations of the form $(\partial\phi_1/\partial P)_{i_1, T, x, x_1, \ldots i_2 \ldots} = (\partial v/\partial i_1) : {}_{P, T, x, x_1, i_2 \ldots}$. With appropriate signs for the differentials, proved in the volume and indicated in the mnemonic rules, they show that, if the permeability increase with the pressure, an increase in the field will, at constant pressure, be accompanied by a decrease in volume. The conditions for stable, unstable, and neutral equilibrium are also very simply obtained from inspection of the equations in both groups.

G. W. DE T.

1589. *Magnetic Field of Circular Currents; Magnetic Forces of Coils.* **H. Nagaoka.** (Phil. Mag. 41. pp. 377–388, March, 1921.)—The author has shown in previous papers [see Abs. 705 (1918)] the suitability of theta functions for calculating the magnetic fields of circular currents, and that their inductances are easily expressible in terms of the ordinary q-series, which are rapidly convergent. Here he applies the latter to obtain expressions of the magnetic force of a single coil and of Gaugain-Helmholtz coils, at points not far from the axis, in powers of the coordinates. The usual method of expansion in spherical harmonics has the disadvantage that each harmonic contains different powers of coordinates calculated from the centre of a single coil, or from the middle point of the axis of double coils, so that deviations of the magnetic force from that at the centre or middle point cannot easily be expressed in power series of the coordinates. On the other hand, by expansion in q-series, we can arrange terms giving the deviations according to their importance in disturbing the field, and map out the distribution of these perturbations, just as we discuss the aberrations of a lens by expanding them in powers of the so-called Seidel's coordinates, and class the deviations according to the orders of the coordinates involved in the aberrations. A series of maps showing the important deviations for both a single coil and the double Gaugain-Helmholtz coils are given, and the method should be of value, as the author claims, for making these calculations with the minimum of labour, in designing galvanometers and other electric instruments, in which a high order of accuracy and the uniformity of the field are a principal aim. The saving of labour is greatest in the case of the Gaugain-Helmholtz coils, since the second-order deviations vanish in virtue of their construction, so that those of the fourth order upward alone require calculation. The corresponding diagram shows at once that the terms of higher order are insignificant, and demonstrates the value of the arrangement for obtaining uniform field. The discussion refers to single-layer coils only.

In winding in different layers a proper section must be selected. For a rectangular section, Maxwell has shown that an important correction, due to the final section, vanishes when the ratio of depth to breadth is as 6 to 5·57.

G. W. DE T.

1590. *Properties of the Ring Electron.* **H. S. Allen.** (Phil. Mag. 41. pp. 113–120, Jan., 1921.)—The author proves a theorem stated by S. B. McLaren [Abs. 341 (1914)], but of which he left no proof on record, that the angular momentum of a magneton of any shape or dimension about its axis of symmetry is $N_m N_e/8\pi c$, where N_e is the number of tubes of electric induction terminating on the surface, and N_m is the number of tubes of magnetic induction passing through the aperture. Combining this with J. W. Nicholson's natural unit of angular momentum [Abs. 1643 (1912)], $h/2\pi$, where h is Planck's constant, it follows that $N_m = h/\epsilon$, where ϵ is the electronic charge. A further relation between h and ϵ given by Lewis and Adams [Abs. 1091 (1914)] leads to a simple expression for the self-inductance of the ring, which may be combined with Rayleigh's formula for the inductance of an anchor ring of circular cross-section [Abs. 1578 (1912)]. By the aid of Webster's expression for the mass of the Parson magneton, and A. H. Compton's estimate for the radius of the ring [Abs. 1533 (1919)], it becomes possible to calculate the most important numerical constants for the ring, and the results as calculated by the author are given in the accompanying table, from which it appears that intense local magnetic fields must exist in the neighbourhood of the magneton.

Properties of the Ring Electron.

Property.	Numerical Value.	Basis for Estimate.
Charge, ϵ	$4 \cdot 774 \times 10^{-10}$ E.S.U.	Millikan's experiments.
Planck's constant, h .	$6 \cdot 558 \times 10^{-27}$ C.G.S.	Lewis and Adams.
Angular momentum .	$1 \cdot 044 \times 10^{-27}$ C.G.S.	$h/2\pi$.
Magnetic flux	$1 \cdot 374 \times 10^{-17}$ E.S.U.	h/ϵ.
	$4 \cdot 120 \times 10^{-7}$ E.M.U.	
Mass, m	$8 \cdot 999 \times 10^{-28}$ gm.	ϵ/m.
Magnetic moment ...	$9 \cdot 232 \times 10^{-21}$ E.M.U.	$\frac{1}{2}(\epsilon/m)(h/2\pi)$.
Radius of ring, a	$1 \cdot 85 \times 10^{-10}$ cm.	A. H. Compton.
Area of ring	$1 \cdot 075 \times 10^{-19}$ sq. cm.	πa^2.
Flux density (average)	$3 \cdot 83 \times 10^{12}$ E.M.U.	$(h/\epsilon) \div (\pi a^2)$.
Self-inductance	$4 \cdot 80 \times 10^{-6}$ E.M.U.	Rayleigh's formula.
Peripheral velocity, v	$6 \cdot 29 \times 10^{9}$ cm./sec.	v/c.
Frequency, n	$5 \cdot 41 \times 10^{18}$ sec.$^{-1}$	$n = v/2\pi a$.
Current in ring, i	$8 \cdot 61 \times 10^{-2}$ E.M.U.	$i = \epsilon n$.
Field at centre	$2 \cdot 93 \times 10^{9}$ gauss.	$F = 2\pi i/a$.

G. W. DE T.

DISCHARGE AND OSCILLATIONS.

1591. *Attachment of Electrons to Neutral Molecules in Air.* **L. B. Loeb.** (Nat. Acad. Sci., Proc. 7. pp. 5–10, Jan., 1921.)—The author examines the mechanism whereby a negative electron liberated in an ionising process attaches itself to a molecule to form an ion. Calculation shows that this mechanism consists in the electron attaching itself to a molecule to form a negative ion, on the average in one out of 250,000 molecular impacts. It has been shown by Francke and Loeb that in pure nitrogen the electron does not attach to form an ion to any appreciable extent. It is therefore assumed that the electron attaches to the oxygen molecule in air. Measurements made in pure oxygen give n as about 50,000. A. B. W.

1592. *Reflection and Re-emission of Electrons from Metal Surfaces; a Method of Measuring Ionising Potential of such Surfaces.* **R. A. Millikan** and **J. G. Barber.** (Nat. Acad. Sci., Proc. 7. pp. 13–18, Jan., 1921.)—The author summarises as follows:—(1) Contrary to current belief there appears to be no such phenomenon as the *direct reflection* of an electron from a copper surface, or if the phenomenon exists at all, the number so reflected at potentials less than the ionising potential is negligible. (2) The result obtained in (1) reveals, therefore, a method of determining with simplicity and with considerable accuracy the ionising potential of a metal surface (the careful determination of the values of such potentials is now being carried out). (3) As the energy of the electronic impact increases, the amounts of re-emission from copper increases up to about 300 volts, from which point on it remains essentially constant. (4) In the case of copper, the number of electrons detached per impinging electron is never found to exceed 1·3. (5) The number of secondaries per electron is somewhat increased by cleaning the surface by heat, and it appears to be somewhat decreased when the temperature of the surface is raised. (6) The max. energy of emission of electrons released by electronic bombardment of copper increases from about 2 volts to about 5 volts as the energy of impact increases from 10 volts to 300 volts.

A. B. W.

1593. *Emission of Electrons under the Influence of Chemical Action.* **O. W. Richardson.** (Roy. Soc., Phil. Trans. 222. pp. 1–43, April 30, 1921.)—It has been shown by Haber and Just [Abs. 1733 (1911)] that, when drops of cæsium or of the liquid alloy of sodium and potassium are attacked at a low pressure by various chemically active gases, the drops lose a negative charge, but not a positive one. The electric currents set up when the drops negatively charged are stopped by the application in a suitable manner of relatively small magnetic fields, showing that the currents are carried by electrons emitted from the drops.

In order to obtain quantitative information concerning this phenomenon and to ascertain the magnitude of the kinetic energy of the emitted electrons and the mode of its distribution among them, the author has investigated the emission of electrons from the liquid alloys, NaK_2 and NaK, under the action of carbonyl chloride, chlorine, hydrogen chloride, and water-vapour at very low pressures, the alloy being dropped through the gas. The various current–e.m.f. curves obtained are similar to those observed with thermionic emission, and are in agreement with a distribution of energy among the electrons corresponding with that which applies, according to Maxwell's law, to the molecules of a gas at about 3300° abs. with carbonyl chloride and about 4900° abs. with chlorine.

T. H. P.

1594. *Pulsating Thermionic Discharges in Evacuated Tungsten Lamps.* **A. G. Worthing.** (Frank. Inst., J. 191. pp. 837–838, June, 1921.)—A certain tungsten ribbon filament in an evacuated lamp bulb was observed to show periodic automatic changes in brightness. Of several other similar lamps investigated, only a few showed similar discharges, and none to the extent exhibited by the first. The variations were found to be directly connected with changes in the thermionic discharges in the lamp. These may take place either from the filament to the insulated electrode in the bulb, or from one leg of the filament to the other. In one test a direct current of 8·2 amps. was used to heat the filament to about 2280° K. The negative terminal of a 44-volt battery was connected to one end of the filament through a voltmeter of 5000 ohms' resistance, the positive terminal being connected to the insulated electrode. The thermionic currents represented by the voltmeter readings showed discharges of a pulsating character in which, without any alteration of conditions by the experimenter, the currents rose from a moderately steady minimum, at first slowly and then very suddenly, to a max. value nearly 5 times the minimum value. The period of discharge, 8 minutes, was constant for 9 successive intervals to within 4 %. Small characteristic variations in the form of the curves were repeated also. Different temperatures of operation, different applied voltages and resistances in the voltmeter circuit, yielded discharges differing in period, minimum and maximum current values, and ratios of max. to minimum current values. Temperatures beyond a certain value and resistances below a certain minimum in the thermionic current circuit, other conditions remaining unchanged, tended toward pulsations which gradually diminished in intensity and disappeared, leaving a steady thermionic discharge. No definite explanation is offered for this action, but the blue glow discharges which were obtainable in the lamps used would seem to indicate that it might be connected with the residual gases in the lamps. A. W.

1595. *Effect of Strong Electrostatic Fields on the Vaporisation of Tungsten.* I. **A. G. Worthing** and **W. C. Baker.** (Frank. Inst., J. 191. pp. 833–835, June, 1921.)—Measurements made with tungsten filaments, with electrostatic fields of 2000 and 800,000 volts per cm. at the surface of the filament, showed no appreciable change in the vaporisation of the filaments due to the electrostatic field. This result is briefly discussed. A. W.

1596. *Effect of Strong Electrostatic Fields on the Vaporisation of Tungsten.* II. **A. G. Worthing** and **W. C. Baker.** (Frank. Inst., J. 191. pp. 835–837, June, 1921.)—Improvements in the method and apparatus used [see preceding Abstract] resulted in considerably greater field strengths, the maximum reached being about $3{\cdot}2 \times 10^6$ volts per cm. The results show a positive effect of strong electrostatic fields on the rate of vaporisation. The effect diminishes with decreasing field strength, and seems to disappear at somewhat less than 10^6 volts per cm. One tube used, however, with a field of $3{\cdot}2 \times 10^6$ volts per cm., did not give the positive effects noted with other tubes. A. W.

1597. *The Passage of Electricity from a Point to a Plane through an Insulating Liquid.* **E. Bellisaj.** (N. Cimento, 21. pp. 310–316, April–May–June, 1921.)—The following are the results of the experiments described :—With equal potentials the current is more intense in paraffin oil, less in vaseline oil, and less still in glycerine (similarly to what has already been observed in the case of dispersion). For any value whatever of the potential, within the limits considered (40 volts to 224 volts), the current from point to disc is much greater when the point is negative than when it is positive. In the case of the negative point the increase of current with increase of p.d. is slow at first, then very rapid ; afterwards it is again slow. In the case of the positive point such increase of current is always more rapid. Tabular and graphical records of the results obtained are given. A. E. G.

1598. *Processes within the Electrode which accompany the Discharge of Hydrogen and Oxygen.* **D. P. Smith.** (Am. Electrochem. Soc., Trans. 34. pp. 177–185 ; Disc., 185–188, 1918.)—The author has observed an effect not previously recognised [Abs. 275 (1917), 96 (1919)], consisting in a diminution of the resistance of the electrode metal during the discharge of hydrogen or oxygen upon it. The results of the experiments made render it probable that such effect is due to the formation of a transient form of the occluded element, which is less closely combined with the solvent metal than is the solute in a solid solution. It is found also that the changes in volume which palladium undergoes during occlusion and subsequent evolution of hydrogen proceed in parallel with the change in the supplementary conductance mentioned. Such changes in volume are probably due, mostly at any rate, to the expansive force exerted by hydrogen in a form distinct from that producing the ordinary increase in resistance during occlusion, and possibly identical with that responsible for the above-mentioned diminution in resistance of the electrode metal during the discharge of hydrogen or oxygen upon it. Various indications are given as to the reactions occurring within the electrode during the discharge of hydrogen. T. H. P.

1599. *The Oscillating Spark.* **W. Moroński.** (Arch. des Sciences, 3. pp. 55–77, Jan.–Feb., and pp. 164–187, March, 1921.)—These papers are not suitable for abstraction. The author gives an historical survey of the subject and methods of measurement used in studying the oscillating spark. In the present work a Wien's condenser is used in a circuit such that the dissipation of energy is due only to the spark and a negligible amount of radiation. The results of a study of the characteristic of the spark and the change in wave-length with the spark-length (observed principally with quenched sparks and with the Poulsen arc) are given. A Fleming's disc is used to record the sparks. Each spark is observed as a line of large intensity in a group of feeble lines, probably due to the discharge of the circuit formed by the capacity and the self-induction of the secondary of the induction coil used to produce the main sparks. On increasing the current in the primary of the coil other intense lines appear, which are not so intense as the lines of the main spark: these are called partial sparks, and form the intermediate stage to quenched sparks. The change of wave-length appears to be a property characteristic of partial sparks. The observation of several methods of quenching, especially those of Kaltenbach and Wien, renders it probable that quenching arises from a stable ionisation of the spark-gap accompanied by partial sparks. The original should be consulted. T. H.

1600. *Sparking Discharge through the Surface of Dielectrics.* **H. Saegusa.** (Tôhoku Univ., Sci. Reports, 9. pp. 423–449, Dec., 1920.)—Investigates the effects of dielectrics on the spark discharge. Test specimens of dielectrics are placed between parallel-plate electrodes and the spark potential is observed. The specimens are of different materials and shapes, *e.g.*, oblique circular cylinders, flat-topped cones, double cones with either flat tops or else bases in common, circular discs, combined surfaces of flat-topped cones, and discs. The spark potential between the parallel plates decreases when a solid dielectric is placed between them. The first spark discharge takes place along the surface, starting from the portion where the surface of the dielectric and the kathode plate are in contact at an acute angle. The spark potential decreases as the inclination of the surface to the direction of the field increases, reaches a minimum, and then increases. This variation of spark potential is of a similar character for every dielectric, but the value of the potential decreases as the dielectric constant increases. The variation, when the surface forms an acute angle with the kathode, is greater than in the similar position with the anode. The form of the lateral surface affects the sparking discharge considerably. The *effect of humidity* on the spark discharge through air is to diminish the potential up to 30 % humidity. With the solid dielectric the variation in spark potential is similar to, but far greater than, that with air, and depends on the direction of the electric field.

With a circular disc the spark potential increases, at first logarithmically, with the diameter of the disc; above 2 cm. diameter (thickness 8 mm.) it remains nearly constant; it increases proportionally with the thickness of the disc. The direction of the lines of force is found by sprinkling well-cleaned minute pieces of hair on to a celluloid plate inserted between the two halves of a section of the solid dielectric. The lines always cut the surface of the dielectric at an angle depending on the inclination of the surface to the direction of the field and upon the dielectric constant; they are concentrated into protruding portions of the surface. This distribution is a cause of the diminution of spark potential. Photographs are given.

A *mathematical theory* is developed, based on the flow of electrons along the dielectric surface, the electrons, originally bound, being dragged from the molecules when the electric force exceeds a certain value. The current produced is calculated. The spark potential for any dielectric is then assumed to be $v_0 - v$, where v_0 is the spark potential with no solid dielectric between the plates, and v is the p.d. corresponding to the calculated current and resistance of the dielectric. The theory agrees, at least qualitatively, with the experimental results. T. H.

1601. *Transmission of Electric Waves Round the Earth's Surface.* **H. M. Macdonald.** (Roy. Soc., Proc. 98. pp. 216–222, Dec. 3, 1920.)—In previous communications [see Abs. 1385 (1916)] the author determined the law of decrease in amplitude of the magnetic force of a train of electric waves emitted from a simple oscillator at the surface of a perfectly conducting sphere as the distance of the receiver, also on the surface, from the oscillator increases, and discussed the effect of imperfect conduction. He justifies the conclusions there arrived at by further analytical details, most of which had been worked out at the time of the earlier communications, but which he had considered it unnecessary to include. He further obtains, by the same methods as before, formulæ which are respectively applicable to different portions of the spherical area by means of which the magnetic and electric forces at any point on the surface can be obtained. But he points out that the expressions at a great distance from the oscillator are of no practical interest. He also criticises G. N. Watson's method of attacking the problem by replacing the series by a sum of residues by means of a contour integral [Abs. 206 (1919)], pointing out that this replacement, which appears to be originally due to Cauchy, has been used by other writers, but that the sum which replaces the series is in general less amenable to treatment than the original series. G. W. de T.

1602. *Transmission of Electric Waves Round the Earth's Surface.* **H. M. Macdonald.** (Roy. Soc., Proc. 98. pp. 409–411, March 3, 1921.)—The author criticises Watson's analysis in discussing the effect of a perfectly conducting layer in the atmosphere at a uniform height above the earth's surface on the transmission of electric waves round the earth [Abs. 1321 (1919)], in that he assumes that the time factor ϵ^{-ikCt} can be removed from all the equations, and that the analytical results thus obtained represent the effect of a simple oscillator placed near the earth's surface. For this assumption is equivalent to assuming that a steady state of oscillation exists in the space between the two spheres, such that at the end of a period the amplitudes of the electric and magnetic forces are identical at each point with the values they had at the beginning of the period. But when the surfaces of both spheres are perfectly conducting, no energy is transmitted across either surface, and therefore, if there be a steady state of oscillation in the space, the total energy therein must be constant. And when there is an oscillator in the space emitting electric waves, there is a finite amount of energy radiated from the oscillator in each period, so that the total energy does not remain constant. It follows, therefore, that there is no such steady state, and the mathematical problem involved cannot be treated by assuming that there is a time factor which can be removed. He indicates the analysis by which the effect of a symmetrical disturbance can be obtained in a simple case and for perfect conductivity. He gives the equation for determining the frequencies and rates of decay corresponding to the Legendre function of order n when the inner sphere, of radius a, is imperfectly conducting, and the outer sphere, of radius b, perfectly conducting, and observes that it can readily be shown that when the conductivity of the inner sphere is of the same order as that of sea water, the rates of decay associated with the frequencies that are of the order of those of the waves of wireless telegraphy are small when $b - a$ is small compared to b; it follows that the time required to establish an approximately steady state is impracticably long [see H. Lamb, "Electrical Motions in Spherical Conductors," Roy. Soc., Phil. Trans. Part II. p. 530 (1883)]. G. W. DE T.

1603. *The Damping Coefficients of Two Coupled Circuits.* **W. Rogowski.** (Archiv f. Elektrot. 9. pp. 427–438, March 10, 1921.)—A mathematical article for determining the damping coefficients of the oscillations of two magnetically coupled circuits, in the most general case of any natural frequencies and dampings whatever. The method adopted is that of differential equations. First, the resultant frequencies are drawn out in the case of zero damping of both the coupled circuits. Afterwards the general equations are considered and by suitable simplifications, assuming that the dampings are small, the expressions for the damping coefficients are obtained. These are: $\alpha_1 = R_1U_1/2L_1 + R_2U_2/2L_2$ and $\alpha_2 = R_1u_1/2L_1 + R_2u_2/2L_2$. Curves giving the values of U_1, U_2, u_1, and u_2 in function of the ratio of the natural frequencies of the two circuits and for various values of the couplings allow of α_1 and α_2 being determined. E. B.

1604. *Damping of Oscillating Circuits Containing Spark-gaps.* **P. Lambossy.** (Arch. des Sciences, 29. pp. 101–136, March, and pp. 213–255, May–June, 1921.)—Electric oscillations excited in a circuit containing a spark-gap furnish, as is known, a deformed resonance curve. This deformation produces two consequences—(1) the values of the sum of the decrements of the primary and secondary circuits, determined according to the Bjerknes method, instead of being constant, diminish from the top to the base of the curves; (2) the observed increase in the sum of the decrements, when an additional resistance is inserted in the secondary circuit, is less than the calculated increase. In the present article the author proves, first, that the discrepancies cannot be attributed to the simplifications made by Bjerknes for obtaining his formula, since a more exact formula set forth in the article is equally unable to explain them. In the second place, accurate experiments lead the author to the conclusion that experimental errors cannot be accountable for the discrepancies above cited. He arrives, therefore, at the conclusion that they are due to the properties of the spark, or more precisely, to the fact that the curve of the decrease of the current with the time is a straight line rather than an exponential curve. The author assumes as the mathematical expression for the real curve $e^{-at}\cos nt$, n being so small that when $\cos nt = 0$, the value of e^{-at} becomes already negligibly small. In this manner the curve is practically independent of the periodic behaviour of the co-sinusoidal curve. The author develops the theory founded upon this hypothesis and finds a good agreement between the experimental and theoretical results, both as concerns the resonance curve and the augmentation of the sum of the decrements. E. B.

1605. *Integral Effect of Two Coupled Oscillation Circuits.* **K. H. Warfvinge.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 15. No. 15. pp. 1–13, 1921.)—A mathematical paper following up the work of Bjerknes, Drude, and others. E. H. B.

1606. *Electric-Wave Transmitter in Metal Box.* **J. B. Collo.** (Ann. d. Physik, 65. 1. pp. 41–50, May 13, 1921.)—This paper gives a theoretical discussion of the case of a transmitter consisting of a Planck oscillator with small logarithmic decrement, situated at the centre of a conducting spherical shell. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1607. *Action of Light on the Thermal Conductivity of Selenium.* **B[ianca] Nannei.** (N. Cimento, 20. pp. 185–200, Nov.–Dec., 1920.)—Bellati and Lussana concluded that light increased the thermal conductivity of selenium, Sieg that it has no appreciable effect. The authoress, repeating their experiments and using a new method of her own, finds that light favours the thermal conductivity, apparently the more so the lower the temperature; but the effect is smaller than that on the electrical conductivity. A. D.

1608. *The Peltier-Effect; Theory and Comparison with Bridgman's Results.* **E. H. Hall.** (Nat. Acad. Sci., Proc. 7. pp. 62–66, Feb., 1921.)—When a current of electricity goes from a metal α, in which the free-electron fraction of the conductivity is $(K_f \div K)_\alpha$, to the metal β, in which the corresponding fraction is $(K_f \div K)_\beta$, ionisation or re-association must take place at the junction according as $(K_f \div K)_\beta$ is greater or less than $(K_f \div K)_\alpha$. The resulting change of condition is the same whether it is assumed that ionisation or re-association takes place after or before the crossing of the interface between α and β. Using each of these hypotheses in turn the author treats the problem mathematically, and using the results given in his former paper [Nat.

Acad. Sci., April (1918)], reaches the expression : $n_\alpha/n_\beta = \epsilon^{(\lambda_\beta - \lambda_\alpha)e/RT}$. This equation has a familiar form, and might have been written down at once as soon as the fact is recognised that the free electrons in the one metal are in equilibrium with those in the other, there being no circulatory motion of the electrons at the junction if the metals are at one temperature. Using the equation given, the value for Π may be expressed as follows : $\Pi = (K_f/K)_\beta \lambda_\beta - (K_f/K)_\alpha . \lambda_\alpha$. The values of Π calculated by means of this formula are compared with those found by Bridgman experimentally. Close agreement is not to be expected, and some of the data used by the author he considers to be faulty. A table is given of the various values of the Peltier heat of various metals against bismuth, both calculated by the above formula and observed. From this it appears that the calculated values are three or four times as great as the observed ; but the author considers that this disparity, before any adjustments have been attempted, is not discouraging. For example, a plausible explanation of the discrepancies may be found in the crudity of the assumption that the number n of free electrons per cm.^{3} of a metal is $n = z\mathrm{T}q$, where z and q are constants.

The theory of the Peltier-effect given in the paper is compared with Bridgman's observations on the magnitude and sign of this effect between compressed and uncompressed pieces of the same metal. Twenty metals, including two alloys, were tested by Bergman, who measured the heat absorbed by unit quantity of positive electricity in passing from uncompressed metal to the same metal compressed, or otherwise expressed, the heat absorbed by (He) electrons in passing from compressed to uncompressed metal. Working from 1 atmo. to 2000 kg./cm.^{2}, and from 0° to 100° C., he found this absorption to be positive throughout in 14 of the metals ; negative throughout in three, cobalt, magnesium, and manganese ; mixed (sometimes + and sometimes −) in three, Al, Fe, and Sn. In terms of the author's theory a positive effect can be accounted for by a decrease of $(K_f \div K)_\lambda$ under pressure, and a negative effect by an increase. A change of about 8 % in the value of $(K_f \div K)_\lambda$ would account for the maximum Peltier-effect between compressed and uncompressed Bi as observed by Bridgman. J. J. S.

1609. *Investigations with the Ebert Ion-counter.* **H. Norinder.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 15. No. 2. pp. 1–19, 1921.)—The paper outlines a series of investigations to examine the effect of the induced charge from electric fields on the accuracy of the Ebert ion-counter. A. B. W.

1610. *Use of 3-Electrode Valve for Measurement of Ionisation Currents.* **J. Malassez.** (Comptes Rendus, 172. pp. 1093–1094, May 2, 1921.)—The author describes a simple arrangement whereby a triode valve functions as an electrometer in the measurement of ionisation currents. A. B. W.

1611. *Sensitive Astatic Torsion Magnetometer.* **R. Dieterle.** (Zeits. Instrumentenk. 41. pp. 89–91, March, 1921.)—In forming the astatic system, two groups of magnets are employed ; each group contains eight magnets 8·8 × 0·3 × 0·15 mm. in size made from thin watch-spring. These were fixed at equal distances and parallel to each other on a sheet of mica, and the two groups were fixed at the opposite ends of a long fine glass rod 0·35 mm. in diameter, the centres of the two systems of magnets being 105·4 cm. apart. The whole is hung from a torsion head, by a quartz fibre 17 cm. long, within a non-magnetic case. The suspended system weighs 0·4 gm., and the instrument is several times more sensitive than those of Kohlrausch and Holborn, and of Semm. A table of comparative figures is given for four of these instruments. [See also Abs. 1814 (1904).] G. E. A.

1612. *A New Form of Standard Cell.* **C. J. Rodman** and **T. Spooner.** (Elect. J. 18. pp. 65–69, Feb., 1921.)—The cell here described is of the cadmium type, but it is made up in a concentric form. The container is made of hard silica glass, and tungsten leads are used in place of platinum. The metal must be cleaned thoroughly, and for this purpose boric acid is used, a thin coating being allowed to remain upon the wire. The container consists of two glass tubes, the inner one being sealed concentrically with the outer one. Comparisons with the usual type of standard cell have shown results to be quite satisfactory. This form gives greater compactness, stability of construction, and smaller local variations in temperature between the parts. W. R. C.

ALTERNATING CURRENTS AND MAGNETISM.

1613. *Magnetic Susceptibility of Low Order.* **E. Wilson.** (Inst. El. Eng., J. 59. pp. 319–329, March, 1921. Electrician, 86. pp. 298–299, March 11, 1921.)—A summary of work, much of which has already been published [Abs. 1159 (1921)]. A table of susceptibilities for minerals, metals, and fluids is followed by a summary of the methods of measurement, namely: the magnetometer, bar and yoke, torsion balance, electromagnetically controlled balance, and the manometer. The susceptibility values and their variations are discussed in the cases of magnetite, ferric oxide, ferrites and sulphides, and a table of transformation temperatures is given. The practical application to magnetic surveys is referred to, and the magnetic separation of ores and metals is well summarised. G. E. A.

1614. *Induction in Rotating Spheres.* **R. Gans.** (Archiv f. Elektrot. 9. pp. 413–426, Feb. 10, 1921.)—The problem of induced currents in a rotating sphere in a magnetic field was attacked by Hertz (1880) and Gans (1901) for small speeds; the general case is here considered. Starting from Hertz's fundamental equations, the solution is obtained and applied to the case of a non-magnetic sphere in a uniform field. The current-lines are found to be circles in planes which, for small angular speeds (ω), are parallel to field and axis of rotation; for very large ω, the currents are on the surface, and make an angle of 45° with the field and the axis. Calculating the amount of heat produced by the currents, it is shown to be proportional to ω for small speeds, and to $\sqrt{\omega}$ when ω is very large. Also there is a critical angular speed which is independent of the field, a property which may be employed for the purpose of automatic regulation of speeds. Finally the paper deals with the energy of the eddy currents and the apparent moment of inertia of the sphere. G. E. A.

1615. *Stationary Magnetic Fields in Electric Conductors.* **I. Herlitz.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 14. No. 22. pp. 1–25, 1920.)

—A mathematical study of the condition of an electric conductor during the establishment of a magnetic field within it. The case is first taken in which a magnetic field of given value is suddenly established at the surfaces of an infinite plane lamina of definite thickness; the solution gives two waves which penetrate from the surfaces, and are thereafter reflected from each surface in turn, with negative sign. In considering the penetration into cylindrical conductors, it is assumed that there are no end effects, and the value of H is found and graphed. Proceeding to the case in which the cylinder is surrounded by a coil to which a constant e.m.f. is applied, the field is again expressed. After the consideration of special cases, the final being the magnetic circuit of a three-phase generator, the author concludes that eddy currents, besides exercising a retarding action on all changes in the magnetic state of electric conductors, sometimes have another, stronger action in causing, during the change, a very irregular distribution of the field. The results apply only to material of constant permeability, but may be applied to the case of iron provided that the changes in magnetisation are confined to values entirely below or entirely above the knee of the magnetisation curve. G. E. A.

1616. *Units of Field Intensity and Magnetic Induction.* **A. Liénard, Brylinski, H. Abraham,** and **Pomey.** (Rev. Gén. d'El. 10. pp. 13–15, July 2, 1921.)—The Congress of Electricians gave the name "gauss" to the unit of magnetic field strength, and in practice the same name is sometimes given to the unit of magnetic induction. The paper contains the chief points of a discussion on this subject at the French Society of Physics. **Liénard** considered that one name should be given to both units; B and H both represent magnetic fields as measured in *crevasses* taken in the magnetic body. **Brylinski** argued that since a definite dimensional formula may be written for μ, the hypothesis that μ is purely a numerical coefficient is improbable and troublesome. Further, magnetic energy per unit of volume for constant μ is $BH/4\pi$; now, all expressions for energy contain two elements, tension and extension, which are essentially distinct; it follows that B is quite distinct from H. **Abraham** pointed out that, admitting that only quantities of the same species can be added, we may have, say, $B = 20{,}000$ in a saturated bar of iron, and on increasing H by 1000, B becomes 21,000. Here is a case of a field added to an induction; they are consequently quantities of the same species. **Pomey** showed that one group of equations for the electrodynamic field is derived from the experiments of Biot and Savart, Laplace's law, and Maxwell's hypothesis of the displacement current; Faraday's experiments on induction give rise to the second group; to these must be added the complementary relations $D = K_0E/4\pi$, $B = \mu_0H$, for vacuum. D is distinct from E and B from H in a vacuum, and consequently also in other media. G. E. A.

1617. *Laws of Induction and Electromagnetic Force.* **R. Cozza.** (N. Cimento, 21. pp. 302–309, April, May, June, 1921.)—A purely theoretical paper, the subject being dealt with by the aid of numerous diagrams. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1618. *Atomic Weight of Chlorine in Minerals.* **[Mlle.] I. Curie.** (Comptes Rendus, 172. pp. 1025–1028, April 25, 1921.)—The author has made a careful comparison of the atomic weights of chlorine (estimated as AgCl) as obtained from sea-water and from a number of very old minerals. The experiments were made with the object of discovering any possible existence of a difference of atomic weight (as indicated by Aston's experiment) which might exist due to a varying ratio of the isotopes combined in the minerals. No certain difference, which could be ascribed to the cause, has been observed. A. B. W.

1619. *Dissolved Gases in Glass.* **E. W. Washburn, F. F. Footitt, and E. N. Bunting.** (Univ. of Illinois, Eng. Experiment Station, Bull. No. 118. [32 pp.], Dec., 1920.)—Describes experiments which show the presence of dissolved gases in various kinds of glasses, viz. barium flint, light flint, and borosilicate. 25 to 50 gm. of the glass was melted and the temperature then raised to 1400° C. An Orsat apparatus was used to analyse the evolved gas for CO_2 and oxygen. The results obtained were as follows :—

Glass.	Weight of Gas (per cent.).		
	O.	CO_2.	N.
Barium flint (1)	0·035	0·011	—
Barium flint (2)	0·015	0·005	—
Light flint..............	0·005	0·014	0·0025
Boro-silicate	0·004	0·0035	0·003

The glasses experimented on were perfectly clear specimens. The importance of this phenomenon in the preparation of glass for high-vacuum apparatus is pointed out. J. W. T. W.

1620. *Universal System of Isotopes.* **A. van den Broek.** (Phys. Zeits. 22. pp. 164–170, March 15, 1921.)—On the basis of Aston's results the author formulates a general isotopic system for all the elements. He considers the fundamental units of the atomic nuclei to be α- and β-particles and suggests the broad outlines of the laws of arrangement to which they conform.

The paper contains a number of tables giving the probable isotopes of all the known elements. A. B. W.

1621. *Rotationary Movements and Absolute Dimensions of Molecules.* **A. Eucken.** (Zeits. Elektrochem. 26. pp. 377–383, Sept. 1, 1920. Paper read before the Bunsen Gesell., Halle, April, 1920.)—The variety of conditions is greater in molecules than in atoms. Diatomic molecules are most conveniently regarded as of the dumb-bell type; in that case the inertia moments J can be calculated, and from these the relative positions of the atoms be deduced. Owing to thermal movement molecules rotate about their centres of gravity; the energy of rotation is $E_r = J\omega^2/2 = 2\pi^2 J\nu_r^2$; all determinations of J are finally based upon this relation. In many cases optical observations admit of conclusions as to ν_r; when the atoms carry opposite charges the rotator will, like an oscillator, either emit or absorb electromagnetic waves (rotation spectrum) which can be measured. The atoms need not even be charged oppositely; some intramolecular monochromatic vibration of frequency ν_0 is sufficient; combined with the ν_r of the molecule, ν_0 gives two observable vibrations, $\nu_1 = \nu_0 + \nu_r$ and $\nu_2 = \nu_0 - \nu_r$ (Rayleigh and Bjerrum), from which ν_r can be determined. J can further be determined from the heat of rotation C_r, *i.e.*, the change of the specific heat of the rotationary movement with temperature. At high temperatures (equipartition presumed) the energy of rotation per mol is $E_r = RT$ or $3RT/2$ (for molecules of 2 or more atoms). When these considerations are applied to a finite mass of gas, the ω will vary and the mean ω^2 will not be the most frequent ω_m^2 (Maxwell), so that $E_r = NJ\omega_m^2$, where N is Loschmidt's number $6{\cdot}07 \times 10^{23}$. With polar charges of the molecules the rotation frequencies will directly be observable (as mentioned), and we get a broad double band in the far infra-red, with 2 intensity maxima, from which ν_m can be deduced. In the cases of HCl, CO, etc., we find these bands in the near infra-red. According to the quantum hypothesis, however, $\nu_r = nh/4\pi^2 J$, that is, the rotator is restricted in its rotations to certain definite frequencies. The intramolecular vibration ν_0 should then show in a number of equi-distant stripes or broad lines $\nu = \nu_0 \pm nh/4\pi^2 J$. Bringing these formulæ in harmony with Bohr's view that there is no radiation during stationary conditions, the author arrives, with Rubinowicz at $\nu = \nu_0 \pm hn/4n^2 J \pm h/8\pi^2 J$. The recent measurements of Sleator (absorption in the infra-red by water-vapour) and Imes (absorption by HCl, etc.), show, however, greater complications. The author discusses these difficulties with respect to the assumption of Lenz that the intensity of a broad line depends only upon the frequency of the static initial condition, and to Heurlinger's method of counting the stripes. Finally he tabulates the values of the molecular moment of inertia $J10^{40}$ by several methods: from the distance of the double bands in the infra-red, from the distances between the stripes in the infra-red, from the band spectrum, from the vapour-pressure curve and the C_r, and from the models of molecules (these last after Laski). The table deals with NH_3, H_2, H_2O, CO_2, N_2, CO, O_2, HCl, HBr, HJ; in each case only some of the methods are available. Contrary to expectation the agreement between the different values is least satisfactory for hydrogen. H. B.

1622. *Analysis of Molecular Volumes from the Point of View of the Lewis-Langmuir Theory of Molecular Structure.* **R. N. Pease.** (Am. Chem. Soc., J. 43. pp. 991–1004, May, 1921. Chem. News, 123. pp. 121–127, Sept. 2, 1921.)—An analysis of molecular volumes, as determined from the critical data, is made from the point of view of the Lewis-Langmuir theory of molecular structure [Abs. 946 (1916); 991 (1919)], and especially of Langmuir's theory of isosteres. Evidence is adduced to show that isosteric molecules and nuclear atoms in hydrogen compounds have the same volume, the latter depending, therefore, on the number and arrangement of electrons surrounding the positive nuclei of the atoms rather than on the charges on the nuclei, that is to say, on the particular kinds of atoms concerned. Thus, it is shown that the nuclear carbon, nitrogen, and oxygen atoms of methane, ammonia, and water, respectively, have the same volume. Further, it is shown that the carbon atoms in ethane, ethylene, and acetylene have volumes increasing with the degree of unsaturation; the same holds as regards the carbon atoms in benzene and cyclohexane. Thus the volumes of atoms increase with the number of electron pairs shared. It is shown further that elementary nitrogen and carbon monoxide probably have the same normal or acetylenic structure, three pairs being shared, rather than the condensed structure suggested by Langmuir. A structure for nitric oxide is suggested, and the volumes of the rare gases are considered from the point of view of Langmuir's hypothesis.

T. H. P.

1623. *Arc Images in Chemical Analysis.* **W. R. Mott.** (Am. Electrochem. Soc., Trans. 37. pp. 665–704; Disc., 704–706, 1920.)—The arc image method of chemical analysis depends on observation with a magnified arc image of the changes in colour of the arc parts in combination with other arc phenomena, especially the nature and position of the deposits on the upper and lower carbons as the materials are fractionally distilled by the arc. The points to which observation is directed consist in: (1) Characteristic modifications in the appearance and behaviour of the arc stream and of the carbon craters. (2) The order of distillation of the materials under the influence of the heat of the arc. (3) The character, colour, position, and form of the distillation deposits on the upper and lower electrodes, and the character of the residues, and also specific modifications of these appearances by addition of suitable reagents. (4) The application of ordinary analytical reactions to the deposits and residues after decomposition, distillation, or separation by the arc.

The method exhibits special advantages in the analysis of all refractory materials, minerals, and compounds, the decomposition of which is most troublesome and tedious by the usual analytical methods. It is of particular value in the case of fluorine, phosphorus, cadmium, zinc, silver, gold, sodium, potassium, barium, calcium, strontium, magnesium, boron, beryllium, aluminium, titanium, zirconium, vanadium, uranium, columbium, molybdenum, tantalum, tungsten and the rare earths; it is least applicable to the non-metallic elements and is not available with the acid radicals or with organic compounds. The delicacy of the method ranges from 0·02 to 1 mgm. for different elements. The major constituents of any mineral, alloy, refractory, or chemical precipitate may easily be identified in less than ten minutes. Distinctive tests and a classified and indexed analytical procedure are outlined for 65 different elements. T. H. P.

1624. *Uranium and its Extraction from Pitchblende.* **G. Gin.** (Am. Electrochem. Soc., Trans. 35. pp. 191–196; Disc., 197–198, 1919.)—The author discusses the occurrence and composition of pitchblende (uraninite), the methods of treatment by which uranium oxide is separated from it when it contains vanadium, and the simplified method for use when vanadium is absent. A method is proposed for purification, involving fusion and electric furnace treatment, to convert most of its constituents into carbides, followed by separations based on the differing properties of the carbides. **S. C. Lind** referred to later developments since Gin's paper was written, emphasising the importance of carnotite as the chief source of uranium and vanadium. Again, uranium instead of being the metal of primary importance in uranium minerals, has now become the by-product, whilst radium has become the primary product whose recovery is sought in spite of its infinitesimal concentration of only one part to 3,000,000 of uranium. This fact has naturally changed the metallurgical situation, and any process for uranium which does not lend itself to the recovery of radium must be abandoned. Uranium is at present not only a by-product, but one that has difficulty in finding a commercial outlet; only a small portion of the uranium being produced in the radium industry is finding a market at the present time. Reference is made to present-day methods of recovery of radium and uranium from carnotite. A. B. W.

1625. *Possibility of Separating Mercury into its Isotopes by Centrifuging.* **J. H. J. Poole.** (Phil. Mag. 41. pp. 818-822, May, 1921.)—Using the data supplied by Aston's positive-ray work on the atomic weights of the isotopes of mercury, the author calculates the change of density to be expected in the "outer" and "inner" samples of mercury obtained by centrifuging. It is shown that it is feasible to construct a centrifuge in the form of a hollow disc which could be run up to at least 60,000 revs. per min.; and such a centrifuge, if its other dimensions were approximately the same, would give a difference of density of about 1·5 parts in 1000, which should be quite easily detectable. The amount of separation might further be increased by successive experiments. Liquid neon might similarly be separated into its isotopes. A. B. W.

1626. *Effect of Quenching on the Properties of Tin Brasses.* **L. Guillet.** (Comptes Rendus, 172. pp. 1038–1041, April 25, 1921.)—After referring to some of his earlier work, in which he showed that certain pure $\alpha + \beta$ brasses had their mechanical properties altered by quenching, the author gives a table showing the results of quenching on the mechanical properties and constitution of a series of copper-zinc-tin alloys containing up to 5 % of tin, both free from lead and in the presence of this element. From these results he deduces, amongst other conclusions, the following: (1) The special constituent which appears on the addition of tin has the same thermal transformations as the δ of the copper-tin series. (2) Above 350° C. it is soluble in the copper-zinc β. (3) Quenching does not cause the disappearance of structurally free lead. (4) Quenching at 600° C. very greatly improves the mechanical properties of alloys containing δ. J. L. H.

1627. *Constitution of Zinc-rich Alloys with Copper and Aluminium.* **J. L. Haughton** and **K. E. Bingham.** (Roy. Soc., Proc. 99. pp. 47–69, April, 1921.)—The authors have investigated the constitution of the ternary alloys of zinc containing up to 10 % Cu and 15 % Al by means of thermal analysis, microscopic examination of annealed and quenched specimens, and electrical resistivity measurements. The constitution of the Cu-Zn alloys containing up to 10 % Cu has been re-determined, resulting in a modification of the equilibrium diagram as given by Shepherd. Both the metals, Cu and Al, are soluble in zinc to the extent of about 1 %. The transformation of the β of the Al-Zn series occurs in the ternary alloys at a temperature which is in agreement with that found by Rosenhain and Archbutt in the binaries. A ternary eutectic is formed (378° C.) whose composition is 4 % Cu, 7 % Al and 89 % Zn, the temperature being only 2 deg. C. below the Al-Zn eutectic. A eutectoidal complex, which does not occur in either of the binary systems concerned, takes part in the formation of the ternary eutectic. This complex consists of β (Al_2Zn_3) of the aluminium-zinc system and ϵ of the Cu-Zn system. J. L. H.

1628. *The Hardness of Solid Solutions.* **W. Rosenhain.** (Roy. Soc., Proc. 99. pp. 196–202, June 1, 1921.)—When one metal dissolves in another in the solid state, the resulting solid solution is harder than the solvent metal. To explain this, the theory is put forward that the crystals of a solid solution of metal B in metal A are built up on the same space-lattice as crystals of pure A, the sole difference being that certain individual atoms of A are replaced by atoms of B. If the two atoms tend to take up a similar space-lattice arrangement, and if their normal interatomic distances do not differ very much, a single crystal may be built up, upon the space-lattice of A, from atoms of A and B indiscriminately, up to a considerable proportion of B. The closer the similarity of the atoms, the larger would be the range of solid solubility, which may vary from 100 % to nearly zero. The actual arrangement of atoms on the space-lattice of A cannot exist entirely undisturbed when some of the atoms of A are replaced by atoms of B, *i.e.*, the space-lattice will be somewhat distorted. From this it follows that the solid solubility of metal B in metal A will be, to a first approximation, inversely proportional to the distortion of the space-lattice of A caused by the substitution of an atom of B for one of A in that lattice. This distortion of the space-lattice also governs the hardness of the alloy. The hardening effect of one metal in solid solution in another, should, therefore, be inversely proportional to its solid solubility. It is not possible to test the truth of this deduction from existing data in many cases, owing to ignorance of the true equilibrium conditions in a large number of alloy systems, and to the lack of strictly comparative data as to the hardness of the alloys. In those cases where the facts are known, however, as, for example, in the case of many copper alloys and some Al alloys, the facts confirm the theory. J. L. H.

1629. *Critical Points due to Work* (*Ecrouissage*). **L. Guillet** and **M. Ballay.** (Comptes Rendus, 172. pp. 1576–1578, June 20, 1921.)—The authors have studied the critical points obtained on heating work-hardened material in two ways—dilatometric methods, and electrical resistivity methods. The materials studied were (1) Cu 67 %, Zn 33 %; (2) Cu 60 %, Zn 40 %; (3) 0·8 % carbon steel. The dilatometric method did not give any very marked results, but the resistivity method, particularly in the case of the brasses, showed the annealing effect very markedly. The apparatus employed in carrying out the resistivity methods is described. J. L. H.

1630. *Retarded Solution and Premature Precipitation of Carbide in Steel.* **A. Portevin** and **P. Chevenard.** (Comptes Rendus, 172. pp. 1490–1493, June 13, 1921.)—Theoretically, the dilatation curve of a eutectoid steel should have but one critical point due to the carbide being dissolved in, or precipitated from, the iron. Practically, it is found that there is a period of dilatation on heating after the A*c* point, which is due to the retarded solution of the cementite. The magnitude of this dilatation is inversely proportional to the rate of heating. If the steel has received a heat treatment such that the cementite is in a globular condition, the dilatation point will be observed on cooling, whereas if the steel has the cementite in a lamellar condition before heating, the point will not appear on cooling. This is due to the steel being non-homogeneous in the first case, certain parts being locally hypereutectoidal.
J. L. H.

1631. *Mechanical and Technological Properties of Alloys and the Periodic System.* **W. Guertler.** (Zeits. f. techn. Physik, 1. 9. pp. 176–181, 1920.)—If we regard metallic compounds differing by 5 % in their compositions as distinct alloys, there would already be 8 million ternary alloys. The enormous variety becomes simpler when considered from the standpoints of inner constitution and of technical utility, depending mainly upon strength, plasticity, and chemical resistivity. In the liquid state metals differ as to miscibility. In the crystalline state, we may have (1) homopolar mixed crystals; melts of 75 Cu and 25 Ni, *e.g.*, give individual crystals of that composition, and such mixed crystals are mainly formed by metals, especially of high melting-point, which are near one another in the periodic system; (2) intermediate heteropolar crystals (*e.g.*, of iron-zinc in a ground mass practically of zinc) of elements far apart in the system; (3) separate crystals, *e.g.*, of Cu in a ground mass of Bi. There may be series of (2) within certain proportions of the constituents; thus brass consists of two kinds of crystals (α, β), both containing Cu and Zn in varying proportions. Arranging the metals (and also P, Te, Se, S) in a diagram in the order Na, K . . . both in the ordinates and abscissæ, the author finds elements of marked miscibility and crystalline character grouped together. When we add further elements to binary alloys, the mutual solubility in the liquid state is increased, the range of (1) is raised, the possibility of (2) not prevented, and ternary and multiple compounds are rarely formed unless the binary elements are known in the (2) crystals. For the technical properties it is important whether or not the metals form (1) or (2) or both; (1) gives useful alloys, (2) brittle alloys. Brittleness and hardness run, on the whole, parallel and are marked with high melting-points and brittleness of the components and their nearness (in the periodic system) to the metalloids. As regards liability to chemical corrosion, the corrodibility of an element is less marked in (1) than in (2). From these considerations the author arrives at a middle group of useful alloys of high melting-point, at a second group of white metals of low melting-point, at a third group of light metals (Al, Mg), and at a further group (or groups) of elements (B, Si, C, etc.) which are suitable only as additions in various proportions and which give rise to characteristic compounds (carbides, etc.).
H. B.

1632. *Influence of Enclosed Slag on the Corrosion of Wrought Iron.* **L. T. Richardson.** (Am. Electrochem. Soc., Trans. 37. pp. 529–534;

Disc., 534–541, 1920.)—The resistance to corrosion shown by wrought iron is explained either by a chemical theory, that is by the purity of the iron, or by a physical theory, that is by its physical structure, which consists of fibres of pure iron throughout the mass of which are scattered long threads of slag or cinder. In order to test the theory that the slag present is of importance to the non-corroding properties, specimens were exposed to atmospheric corrosion for periods up to 2 years, longitudinal and transverse sections of each specimen being prepared. It is suggested that in a direction perpendicular to the slag layers the metal is not continuous and any oxidation of the metal, as it penetrates inwards from the surface, must meet layers of slag. In the other direction, however, that is, parallel to the layers of slag, the metal is continuous and as the corrosion penetrates, it will not meet these layers of slag. Hence, if corrosion is retarded by slag inclusions, as insisted on by the adherents of the physical structure theory, transverse sections of wrought iron should rust more rapidly than longitudinal sections.

The results obtained show that the amount of corrosion in the two directions is the same within the limits of experimental error, and the conclusion arrived at is that any superior resistance to corrosion that wrought iron may have is not due to slag inclusions but to some other cause, such as the purity of the iron. C. O. B.

1633. *Improving Grey Iron by the Electric Furnace.* **G. K. Elliott.** (Am. Electrochem. Soc., Trans. 35. pp. 175–181; Disc., 181–186, 1919.)—Proposes the use of a basic-lined arc electric furnace to take grey iron from a cupola, to refine and superheat it for the manufacture of special castings such as steam valves for high-pressure and superheated steam, engine cylinders, etc. It is pointed out that the cupola is economical for heating and melting but poor as a superheater and from the point of view of regulation of carbon, waste of alloying metals, and impossibility of refining. The duplex process, using the electric furnace in conjunction with the cupola, corrects and supplements the deficiencies of the cupola. It is also proposed to use the electric furnace on direct metal from the mixer, to assure a superior quality of melted iron at a proper temperature for the foundry. C. O. B.

1634. *Nature of Secondary Valence.* **H. W. Smith.** (J. Phys. Chem. 25. pp. 160–169, Feb., 1921.)—Secondary valence is defined as the force which binds molecules together and is regarded as the chemist's name for the cohesion of the physicist. It is usually assumed that the attraction of one molecule for another is to be attributed to stray electric fields surrounding the valence electrons of the atom, that molecular configuration plays an important part in determining the attraction between two molecules, and that the force acting between two molecules is subject to treatment on the basis of the inverse square, or the inverse fourth power, or some such mathematical function of the distance which it is supposed separates them. The author regards all three of these assumptions as erroneous, evidence derived from a study of organic compounds being presented to show that the forces acting between molecules are comparable with those forces in the atom which are responsible for atomic structure, in that they are rhythmic in nature and consequently not subject to treatment under familiar electromagnetic laws. A study of various physical phenomena indicates that molecular volume is a deter-

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mining factor in practically all the phenomena associated with liquids. The question of partition coefficients is discussed and analysis of the relations between these coefficients in terms of molecular volume shows: (1) that, in any series of compounds having the same intrinsic intensity of secondary valence the partition coefficient is a simple logarithmic function of the molecular volume; (2) that secondary valence is rhythmic in character, varying in different molecular species by definite and related amounts. These variations in secondary valence are expressed in the partition coefficient by increases or decreases of constant arithmetic value and are attributable to variations in the state of one or two particular atoms in the molecule having their origin in the mode of chemical combination. T. H. P.

1635. *Influence of the Geometrical Form of Solid Substances on the Chemical Actions they undergo.* **G. Reboul** and **R. Luce.** (Comptes Rendus, 172. pp. 917–918, April 11, 1921.)—As with chemical action between solids and gases [Abs. 915 (1913)], so also with that between solids and liquids, the velocity of reaction is a function of the geometrical form of the solid, being greatest where the radius of curvature is the least. T. H. P.

1636. *Molecular Size and Range of Molecular Attractions in Solutions.* **J. B. Leathes.** (Nature, 107. pp. 138–139, March 31, 1921.)—On the assumption that molecules are spherical and exert attraction throughout a spherical space, it is shown that, in passing from molecules of the dimensions estimated for those that give true solutions to molecules of the size compatible only with colloidal solution, a very great change in the behaviour of a solvent such as water must be observed. If the relations between the molecules of solvent alone are considered, the force tending to withdraw these molecules from the surface of molecules of solute is found to increase eight-thousandfold. The large molecules must be far more unstably dispersed than the small. As soon as they come within a distance from each other less than the radius of attraction for the solvent, they will be forced together by the internal pressure of the solvent. The force tending to remove a molecule of solvent from the surface of a particle 100 Ångström units in diameter is more than $\frac{5}{8}$, say 75 % of the internal pressure at a plane surface; for a starch molecule 50 units in diameter it is, say, 33 %; for a molecule 25 units in diameter, say 5 %; and for a CO_2 molecule 2·5 Ångström units in diameter, say 0·005 % of the internal pressure at a plane surface.

In the above consideration of the condition obtaining in solutions no account is, however, taken of any forces except those acting between the molecules of solvent. T. H. P.

1637. *Potential of Metals.* **U. Sborgi** and **A. Donati.** (N. Cimento, 21. pp. 211–258, April–May–June, 1921.)—Measurements have been made of the potentials of cadmium, copper, and silver: (1) in aqueous solutions of their own salts increasing in dilution from about normal strength to a point at which uncertain results are obtained; (2) in similar solutions containing also an extraneous salt in definite concentration; and (3) in the solution of the extraneous salt alone: the extraneous salts employed have the same anion as the other salts. Use was made of the Poggendorf compensation method of measurement, a Lippmann capillary zero electrometer being employed.

The results obtained, given as tables and curves, are perhaps insufficient to lead to any general conclusions, but the following points are brought out: The potential of the metal in the solution of its own salt is regularly a logarithmic function of the concentration of the salt, but when the latter reaches a certain value the variation of the potential with the concentration becomes minimal. This phenomenon is the more remarkable in that it makes its appearance at high dilutions, that is, when the dissociation is presumably complete or almost so and when the variation in concentration of the salt coincides with or closely approaches the variation in ionic concentration. The less electro-negative the metal, the sooner does the bending of the logarithmic curve showing this phenomenon appear; thus, with the more electro-negative metals the bending of the curve is detectable only in presence of an extraneous electrolyte, since, in absence of the latter, the measurements cannot be conducted with sufficient accuracy for dilutions of the metallic solutions beyond a certain point.

The value assumed by the potential of the metal in an extraneous electrolyte alone falls on the asymptote of the curve obtained when the solution contains, besides the extraneous electrolyte, the metallic salt in gradually increasing dilution. The addition of the extraneous electrolyte renders the potential more positive, this being attributable to retrogression of the dissociation; further, the influence of the extraneous kation on the potential of the metal is determined by the position of the kation in the potential series. T. H. P.

1638. *Rate of Change of Distribution of Particles in Colloidal Systems.* II. **A. Westgren.** (Ark. f. Mat., Astron. och Fysik., Stockholm, 13. No. 14. pp. 1–18, 1919.)—The author has tested experimentally various formulæ derived by v. Smoluchowski [see Abs. 431 (1917)] for the rate of change of the concentration of the particles within a cylindrical volume of a colloidal solution. The experimental results obtained are in good agreement with the theoretical requirements. The formulæ in question permit of a determination of Avogadro's constant, for which several series of experiments lead to the value $60 \cdot 9 \times 10^{22}$, with an accuracy of 5 %.
T. H. P.

1639. *New Method of Measuring Electrolytic Conductance.* **C. Marie** and **W. A. Noyes, Jr.** (Am. Chem. Soc., J. 43. pp. 1095–1098, May, 1921).—Comparison is made between electrolytic conductivities as measured by the ordinary Kohlrausch method and those measured under exactly similar conditions on the same bridge by a direct-current method; for the latter two hydrogen electrodes of exactly equal potential are placed in the solution and an ordinary d.c. Wheatstone bridge is used to determine the resistance. With solutions of various concentrations of sulphuric, hydrochloric, oxalic, citric and succinic acids and sodium chloride, the differences between the results obtained by the two methods are negligible, except for sulphuric and hydrochloric acid solutions of greater concentration than $0 \cdot 5\ N$. T. H. P.

1640. *Electrolytic Chromium.* **G. J. Sargent.** (Am. Electrochem. Soc., Trans. 37. pp. 479–496; Disc., 496–497, 1920.) [Abs. 1510 (1905).]—Adherent deposits of chromium were obtained from chromic acid solutions containing small amounts of chromic sulphate. The lower the current density, the thicker the deposit of Cr obtainable. At low temperatures, a high current-efficiency is obtained at comparatively low current-densities. A deposit 1·25 cm. thick with a yield of 0·1 gm. Cr per amp.-hr. was obtained from a solution containing 24·5 % CrO_3 and 0·3 % $Cr_2(SO_4)_3$ at a temperature of 20° C., a current-density of 10 amps./dm.^{2} of kathode, an electrode distance of about 2·5 cm., and a p.d. of 3 volts. No advantage was gained by the use of a rotating kathode. The deposited chromium is usually of a light grey colour, and is practically unaffected by air, oxygen, or chlorine at temperatures up to 300° C.

Lead was found superior to platinum as anode substance, as with lead anodes the chromic acid reduced at the kathode is oxidised back to chromic acid at the anode.

The deposition of chromium from these solutions is apparently preceded by the formation on the kathode of a brown film of basic chromic chromate of the formula $CrO_2 . CrCrO_4$, or $Cr_2O_3 . CrO_3$. The formation of this film is usually accompanied by a sudden increase in the voltage between the electrodes and by the evolution of hydrogen at the kathode. At this stage, there is a partial reduction of chromic to chromous ions and the deposition of chromium occurs from chromic and chromous ions. At lower current-densities and in absence of the formation of this film, chromic acid solutions are reduced practically quantitatively to chromous ions. J. N. P.

1641. *A Process for Electrolytically Refining Nickel.* **G. A. Guess.** (Am. Electrochem. Soc., Trans. 35. pp. 259–262; Disc., 263–264, 1919.)—An anode of crude nickel containing copper and iron is electrolysed in a bath of nickel sulphate in which is suspended calcium carbonate. The kathode is enclosed in a canvas bag and the deposited Ni is practically free from iron and usually contains less than 0·001 % of Cu. A small amount of glue is added to the electrolyte. Iron accumulates mainly in the electrolyte, while the calcium carbonate leads to the formation of the compound $2CuO . 2NiO . SO_3$, which is insoluble. A current-density is employed of 13 amps. per sq. ft. of kathode, with a p.d. of 2 volts and a current efficiency at the kathode of 98 % is obtained. Platinum and palladium are retained in a slime which forms an adherent deposit on the anode.

The basic sulphate collects as a mud and on fusing with silica as a flux in graphite crucibles gives a nickel-copper matte. The matte is roasted to remove the sulphur, giving an alloy which is cast into anodes from which copper can be obtained by electro-deposition and the nickel recovered as sulphate. J. N. P.

1642. *Electro-Plating on Iron from Copper Sulphate Solution.* **O. P. Watts.** (Am. Electrochem. Soc., Trans. 35. pp. 265–273; Disc., 273–278, 1919.)—Adherent electrolytic deposits of copper from a sulphate solution are obtained on iron by first immersing the iron in solution of salts of various metals which lie electrochemically between iron and copper. In different experiments, a preliminary immersion of the metal was made in solutions of arsenious oxide dissolved in hydrochloric acid, lead fluosilicate, antimony chloride, together with magnesium chloride, bismuth chloride, and acidified tin chloride. Except in the cases of bismuth and tin solutions, good subsequent deposits of copper were obtained by electro-deposition. Adherent electrolytic deposits of nickel were obtained on Al by a preliminary immersion of the cleaned Al in dilute hydrochloric acid containing 1 % of ferric chloride.

As in the beneficial effect obtained in plating silver on copper or brass by a preliminary immersion of the metal in a solution of a mercury salt in potassium cyanide, the mechanism of these reactions consists in lowering the potential of the metal to be plated so that corrosion by the electrolyte is diminished. J. N. P.

1643. *The Preparation of Fluorine.* **W. L. Argo, F. C. Mathers, B. Humiston,** and **C. O. Anderson.** (Am. Electrochem. Soc., Trans. 35. pp. 335–345; Disc., 345–349, 1919.)—Experiments on the preparation of fluorine were made by electrolysing anhydrous hydrofluoric acid containing potassium hydrogen fluoride. Both the Moissan cell and the cell as modified by Meslans were tried. The method was found impracticable for preparing fluorine in quantity on account of the corrosion of the anode whether this was of Pt or graphite. By heating lead fluoride, which is conveniently prepared by fusing lead peroxide with potassium hydrogen fluoride in a copper vessel, fluorine was obtained, but only in small amounts. A method of preparing fluorine in quantity was found which consists in electrolysing fused potassium hydrogen fluoride. The electrolysing vessel which served as kathode was of heavy copper 9 cm. diam. and 20 cm. deep. The salt was raised to its melting-point (200° C.) by passing a current through nichrome wire wound round the vessel and insulated from the walls by asbestos paper and on the outside by asbestos wool. The anode consisted of graphite centrally placed and surrounded by a diaphragm 5 cm. in diam. and provided with a number of slots near the base to diminish the resistance of the cell. The graphite anode was attached at the top to a copper terminal and was insulated from the lid of the electrolysis vessel by finely-powdered fluorspar held closely and firmly round a copper bolt by means of a packing gland and nut. A considerable amount of space was allowed below the anode for the collection of potassium fluoride. As the bath slightly dissolves copper, it was found necessary occasionally to dissolve the electrolyte in water, and filter off the impurities. During this operation anhydrous hydrofluoric acid necessary to regenerate the electrolyte was added to the cell.

With a fresh bath, in order to electrolyse out the water, a current of 2–3 amps. 1 dm.^{2} was passed until fluorine was evolved, when the current was increased to 10–12 amps. per 2·5 cm. of anode immersed. The usual voltage was 15, the temperature 240°–250° C. and the current efficiency about 70 %. J. N. P.

1644. *Bronze Plating.* **F. C. Mathers** and **S. Sowder.** (Am. Electrochem. Soc., Trans. 37. pp. 525–528, 1920.)—Bronze, a copper-tin alloy, can be plated or electro-deposited from the oxalates of copper and tin dissolved in ammonium oxalate or from a mixture of potassium copper cyanide, potassium stannate, potassium cyanide, and potassium hydroxide. The bath containing cyanide is better. A careful adjustment of the relative quantities of copper and tin in the baths is necessary. AUTHOR.